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SELECTION OF COFFEA SPECIES AND VARIETIES RESISTANT TO COFFEE RUST IN THE PHILIPPINES 1/

F. T. ORILLO and R. B. VALDEZ 2/

A world collection of different species and varieties of coffee, all grown from seeds, received by the College of Agriculture and Central Experiment Station at Los Banos, Laguna in 1954, through the U.S.D.A., and seeds directly obtained from domestic sources and from other countries are being maintained and their reactions to coffee rust (Hemileia vastatrix B. et Br.) are also currently studied in the Philippines.

These coffee collections, with emphasis on the Arabica varieties, were inoculated and screened for rust resistance in the laboratory and in the field. The procedure involved at least two repeated inoculations during the seedling stage in the laboratory or nursery. After each successful inoculation, extremely susceptible plants were discarded while the promising plants were saved, reinoculated further, planted in the field and were either artificially inoculated with rust spores collected from different domestic sources or planted side by side with known rust-susceptible trees already infected. Repeated artificial inoculations were carried out for several seasons.

The results of the screening test from 1955 to 1959 showed 13 Arabica selections to be highly resistant to coffee rust. Nine of these selections came from Africa and bear U.S.D.A. accession numbers 205111, 205935, 205936, 205937, 205939, 205940, 205941, 205928, and 205411 while the other four selections came from India with numbers S.288, S.333, S.446, and S.795. The results of three rust inoculations on the seedling-progeny of the African selections indicated that resistance was dominant and that the percentage of susceptible seedlings varied between the different selections, with 205111 and 205937 as having the least followed by 205935 and 205411, the most. The percentage of susceptibility of the Indian selections ranged from 0 to 19.35 per cent with S.446 as the least resistant.

The other selections that exhibited moderate resistance to the disease were those bearing accession numbers 207629, 205112, 213453, and 205107. The progeny of these selections, however, showed a higher degree of heterozygosity for resistance.

The seedling-progeny of plant number 387, a hybrid between C. arabica x C. dewevri from Brazil, was found to be as highly resistant as the seedling-progeny of Kawisari B, a hybrid between C. arabica x C. liberica from Java.

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Research Project No. 1201.

2/ The authors are grateful to Dr. A. G. Newhall, former Visiting Professor of Plant Pathology, under the Los Banos-Cornell Contract, for his valuable assistance during the early stage of this project. Thanks are also due Messrs. T. T. Reyes, A. N. Pordesimo, and L. C. Orejudos for their help in greenhouse and field experiments.

The other coffee species that were noted to be resistant to the rust disease were C. eugenoides, C. stenophylla, C. canephora, and C. liberica-abeokutae.

None of the local Arabica collections and also none of those that came from Central America were found to have resistance to coffee rust.

Coffee occupies an important place in world economy, and its potentialities in the world market are enormous. In world trade, coffee holds first place as one of the enjoyment goods, surpassing alcoholic drinks, tea and tobacco, and in world international trade, it ranks fifth among all agricultural products (Wickizer, 1943; Di Fulvio, 1947; Wellman, 1955).

Of the reportedly 50 to 80 different species of coffee, only four produce the coffee of commerce viz., *Coffea arabica, C. canephora* (*C. robusta*), *C. liberica, and C. excelsa* (Bartolome, 1950; Haarer, 1956; Carvalho, 1958; Wellman, 1955, 1958). *Coffea arabica* has the finest quality and constitutes approximately 82 per cent of the total world production (Krug, 1958). Unfortunately, this species is very susceptible to the most serious Oriental coffee disease, coffee rust, caused by *Hemileia vastatrix* B. and Br. This disease has devastated the once flourishing Arabica coffee industries of Ceylon, the Philippines, and Java during the last quarter of the 19th century (Ward, 1882; Africa, 1918; David, 1926, 1928; Venkatarayan, 1946-47; Wellman, 1953) and of Transvaal and Southern Rhodesia during the turn of the 20th century (d'Oliveira, 1958). It is serious in about 20 of the coffee growing countries in the Eastern Hemisphere where it is still exacting too much toll besides increasing the cost of production. Whenever chemical protectants are employed, only expensive and partial control is being achieved.

The most logical approach to the solution of the coffee rust problem is the development of Hemileia-resistant or —immune Coffea species, particularly Arabica, because the Liberian and Canephora species, although reputed to be generally resistant to the attacks of Hemileia, were reported to lose resistance after prolonged exposure to the disease (David, 1928). Furthermore, the inferior quality of the other species also limits their planting into new land.

The discovery of the rust-resistant Kent's Arabica in Mysore, India in 1911 (Brizi, 1934; d'Oliveira, 1958) was an important landmark in the Arabica improvement. However, the thought of having solved the rust problem with this discovery was nullified

by Mayne (1932, 1936) who reported that two strains of the rust fungus were able to infect it. The researches at the Balehonnur Coffee Research Station in India on breeding and selection of Arabicas resistant to coffee rust which started as early as 1915 were most fruitful. Among the most promising selections are S.288 and S.795. They are now under large scale distribution over South India (Krug, 1958).

Recognizing the potential threat of the disease to inter-American economy, the United States government sent a mission, under the Point IV Program, to the Eastern Hemisphere in 1952 to study and help solve the coffee rust problem (Wellman, 1953). Henceforth, a collection of varieties and selections of different species of coffee, all grown from seeds, are being maintained and their reactions to Hemileia rust are currently studied in the Coffee Rust Research Center in Portugal and also in other cooperating countries such as India and the Philippines.

In February, 1954, the first shipment of coffee seedlings representing the above collection was received by the College of Agriculture and Central Experiment Station at Los Baños, Laguna through the Plant Introduction Section, Horticultural Crops Research Branch, Agricultural Crops Research Service, U.S.D.A., Beltsville, Maryland. With the subsequent shipments from the U.S.D.A. and seeds directly obtained by Dr. A. G. Newhall from domestic sources and from other countries, the U.P. College of Agriculture has now in its collection a total of 223 entries (accessions) of *Coffea arabica,* 11 entries of *C. robusta,* 2 entries of *C. eugenoides,* and 1 entry each of *C. stenophylla, C. ligustroides, C. liberica-abeokutae, C. racemosa,* and *C. dewevrei.* Although all of these have been tested and some are still being observed for their reactions to coffee rust under laboratory and field conditions, the present paper deals, for the most part, with results of intensive inoculations on the Arabica varieties.

Methods of inoculation. At the start of the work two methods of inoculation were employed, namely, the "camel's hair brush" [3/] and the "atomizer" methods. The former method is briefly described thus: Scrape off a certain amount of uredospores from the margin of a rust pustule with a scalpel, drop them on the nether surface of the leaf to be inoculated, smear them over the

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3/ Method employed and described by d'Oliveira in his correspondence with Dr. A. G. Newhall on Oct. 11, 1954.

surface with the aid of a camel's hair brush, and atomize the inoculated areas with fresh water. Keep the inoculated plants in a moist chamber for about three days and then move them to the glasshouse benches for observation.

The camel's hair brush method is effective, but the writers found it to be tedious and time-consuming for mass screening purposes. The workers, therefore, tried the atomizer method which involves the use of a De Vilbiss No. 15 atomizer and found it comparable in effectiveness with the camel's hair brush method. Uredospores from the rust pustules, free of white molds and larvae of *Cecidomyia* sp., were scraped with a dull scalpel and collected into a clean dry vial. When the desired amount has been collected, distilled water was added into the vial, shaken thoroughly to keep the spores in suspension, transferred into an Erlenmeyer flask and diluted to about 1:300 with distilled water. This suspension of rust spores was used as inoculum.

Ward (1881, 1882), Mayne (1930), and d'Oliveira (1955) showed that the rust fungus gets into the tissues through the stomata and that no infection occurs when the inoculum is placed on the upper surface of uninjured coffee leaves. Similar attempts by the present workers to obtain infection through the upper leaf surface also yielded negative results. According to these earlier investigators, half-developed leaves were most suitable for inoculation to obtain maximum infection. This has also been corroborated by the present studies. In all cases therefore, atomizer inoculation was directed to the undersurface of half-developed leaves.

The first screening was done on potted seedlings in the greenhouse or on seedlings in nursery beds and the second screening was done on promising rust-resistant plants grown in the field. When inoculation was done on potted plants, they were first incubated in a moist chamber for 48 hours and then placed on the greenhouse beds for observation. In the nursery beds or in the field, inoculations were made during damp and cloudy days or late in the afternoon during rainless days. Usually the first symptoms appeared within a period of 7 to 21 days in either condition. In a good moist chamber, the undersurface of the leaves of the incubated plants become watersoaked, a condition which probably facilitates penetration of the germ tubes. Watersoaked condition was likewise

observed when inoculations in the nursery or in the field were immediately followed by nights of heavy mist and dew. Experience showed that under these conditions, maximum infection was always obtained. A similar observation was reported in India where the severity of annual attacks of coffee rust is largely determined by the amount of heavy mist and dew occurring during rainless months (Mayne, 1930). In all inoculations, known rust-susceptible Arabica plants were also inoculated to check the viability of the rust spores used and to serve as a basis for comparing the performance of the varieties under test.

Method of screening. In all the tests made, inoculation and screening were started during the seedling stage and carried through the bearing stage in the case of promising selections. An individual record was kept for each promising rust-resistant plant.

Two types of disease indexing were employed in making the disease readings viz., the laboratory index (d'Oliveira, 1955) and the field index. The former is used by d'Oliveira in Portugal while the latter is a modification of the former to suit field conditions. The indexes (rust reaction symbols) used were:

Laboratory Index

I — immune (no infection symptoms).
Fl — flecks (very slight infection symptoms).
T — small tumors at point of entrance, no further symptoms or development.
C — chlorosis at point of entrance, but no formation of uredo-pustules.
1 — strong chlorosis and small uredo-pustules.
2 — strong chlorosis and medium uredo-pustules.
3 — large uredo-pustules surrounded by chlorotic tissues.
4 — large uredo-pustules with no chlorosis (high congeniality or susceptibility).
x — heterogeneous reaction, more than one type on the same leaf.
1/4 — different individual plants of the same accession showing distinct reactions.

Field Index

0 — no infection symptoms, specks but no spores.

1 — high resistance (plants with slight rust infection, infected leaves do not drop even up to the height of rust infection).
2 — slight to moderate resistance (so-called "field resistance").
3 and 4 — susceptible:
3 — leaves covered with heavy rust infection, but not yet totally defoliated at the time of rust reading.
4 — almost totally defoliated due to rust infection at the time of rust reading.
x — missing hills (dead) at the time of rust reading.

For inoculations in the laboratory, rust readings were made 1 to 2 weeks after the appearance of the first discernible symptoms and 4 to 5 weeks under field conditions. At least two inoculations were made during the laboratory or nursery screening. After each successful inoculation, extremely susceptible plants were discarded while the moderately resistant together with the uninfected ones were saved and reinoculated further. Promising plants were saved, planted in the field and were either artificially inoculated with rust spores collected from different domestic sources or were planted side by side with known rust-susceptible coffee trees already infected. Repeated artificial inoculations were carried out for several seasons.

Since different sets of conditions may cause variation in the reactions of the plant and influence the activity of the rust fungus, the necessity of testing these selections in different places appeared imperative. Part of the first shipment, therefore, was planted in three experimental stations of the Bureau of Plant Industry (Baguio Experiment Station, Lagalag Experiment Station, and Davao Experiment Station) and at the Matutum Agricultural Development Corporation in Mindanao. Rust-resistant progenies of the promising selections were subsequently sent to other private cooperators in selected areas of the country for further observations. These cooperative plantings are being observed from time to time for their reactions to the rust disease and for their desirable agronomic characteristics. They are artificially inoculated with spores of the rust fungus whenever necessary. No fungicidal materials are applied on all the experimental plants; however, insecticides are occasionally sprayed to preclude insect attack.

Trees that have consistently resisted or have at least shown a certain degree of field resistance to the disease are noted. Individual harvests from selected trees are germinated and transplanted

separately in nursery beds. Known rust-susceptible seedlings are planted side by side with the resistant selections to serve as check. As soon as sufficient rust spores are available, which usually coincides with conditions favorable for infection, these progeny selections are again inoculated and screened. Susceptible seedlings are marked to serve as sources of inoculum for the resistant plants during the season. After every 3 or 4 weeks from the first inoculation of seedlings in the nursery beds, reinoculations are made to ascertain the resistance of the plants and to reduce the possibility of "escapes".

RESULTS AND DISCUSSION

The screening of coffee for rust resistance in the Philippines showed 13 Arabica selections to be highly resistant to coffee rust. The rust-resistant trees of nine selections from Africa bearing U.S.D.A. Plant Introduction (P.I.) numbers 205111 (K.7), 205937 (H.66), 20539 (K.P.228), 205936 (H.1.), 205941 (K.P.423), 205935 (F.840), 205940 (L.P.263), 205928 (Geisha), and 205411 (Cioiccie) have remained consistently resistant during the past five years of observation in the field (table 1).

Krug and Carvalho (1952) stated that Arabica coffee is 91 to 93 per cent self-fertile. The possibility of getting true-to-type plants through sexual multiplication from these resistant parents was explored. Hence, a study on the reaction to coffee rust of the seedling-progeny of eight rust-resistant Arabica selections was made to find out whether or not these resistant parent trees were already homozygous for rust resistance. The seeds of all these trees during the first harvest were planted in four (5 x 180 ft.) nursery beds and were inoculated three times during the period from September 21, 1957 to January 2, 1958. The results are given in table 2.

It was observed that the percentage of rust-susceptible seedlings varied between the different selections, with 205111 and 205-937 as having the least followed by 205935 and 205411, the most. Heterozygosity for rust resistance was also noted among the trees of the same accession. Representative plants of these rust-screened seedling-progeny were planted in the field, exposed to severe natural infection, and disease reading was made during the height of rust infection. The results are given in table 3. In general, the performance of the progenies indicated that resistance is dominant in

TABLE 1.—*Rust reading on selected Arabica introductions screened for rust resistance in the College Farm for a 5-year period*

Year a/ Rust Reading Made	ACCESSION NUMBER 205111 Row & Hill No. 15 16	17	18	19	20	23 11	205937 Row & Hill No. 16 1	2	3	4	5	12	205935 Row & Hill No. 16 13	14	15	22 8	1	205939 Row & Hill No. 14 2	3	4	5	22 21	205940 Row & Hill No. 9 15	17	18	19
1955	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1
1957	1	1	1	0	0	0	0	1	0	0	0	0	x	1	1	1	1	1	1	1	1	1	0	0	0	0
1958	1	0	0	1	0	0	0	0	0	0	0	1	x	0	0	0	0	x	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0	x	0	x	0	0	0	0	0	0

Year a/ Rust Reading Made	ACCESSION NUMBER 205936 Row & Hill No. 14 16	18	19	20	19 16	17	18	20	205941 Row & Hill No. 13 11	12	13	14	15	22	205928 Row & Hill No. 14 6	7	8	9	10	205411 Row & Hill No. 23 2	1	2	3	4	5
1955	1	3	0	0					0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1	0
1956	3	3	1	1	0	2	0	1	0	1	0	1	1	1	0	0	0	0	0	1	0	1	1	1	1
1957	4	3	1	2	1	3	1	0	0	0	0	1	1	1	0	2	0	2	2	1	0	1	2	1	1
1958	x	4	0	1	1	4	1	0	1	1	1	1	1	1	1	0	1	1	1	0	0	0	2	1	x
1959	x	4	0	0	0	4	0	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	x

a/ Rust reading taken at the height of infection and when the effect of drought on defoliation has not yet started.

TABLE 2.—*Results of 3 coffee rust inoculations on the seedling-progeny of 8 rust-resistant Arabica selections*

Accession Number	Number of Parent Trees	Total Seedlings Inoculated	RESULTS AFTER 3 INOCULATIONS					
			Number of Plants			Average Percentages of Plants		
			Susceptible	Moderately Resistant a 1/	Not Infected	Susceptible	Moderately Resistant	Not Infected
205111	5	228	1	1	226	0.44	0.44	99.12
205937	5	1358	10	59	1289	0.74	4.34	94.92
205939	4	1192	132	49	1011	11.07	4.11	84.82
205928	2	378	49	112	217	12.96	29.63	57.41
205936	6	1439	243	25	1171	16.89	1.74	81.38
205935	2	739	30	3	706	4.06	0.41	95.54
205941	6	1021	184	76	761	18.02	7.44	74.54
205411	4	666	163	219	284	24.48	32.88	42.64

a/ — Plants showed rust infection but with very few or no spores on the lesions.

TABLE 3.—*Reaction to coffee rust (natural infection) of the "rust-screened" seedling-progeny of rust-resistant Arabica selections under field condition.*

SELECTION NUMBER	Total Seedlings Planted	Number Living at Rust Reading	DISEASE INDEX AND NUMBER FOR EACH				
			0	1	2	3	4
205111	36	35	35	—	—	—	—
205937	35	32	32	—	—	—	—
205935	32	32	32	—	—	—	—
205939	28	23	23	—	—	—	—
205936	32	31	28	—	—	1	2
205941	30	30	26	1	—	1	2
205411	37	24	10	10	—	4	—
205940	8	8	8	—	—	—	—
205928	37	31	31	—	—	—	—

all the selections. However, further progeny-testing is necessary in order to isolate trees that are homozygous for resistance to rust.

Inoculation on two separate batches of seedlings of the four selections from India bearing accession numbers 3.288, S.795, S.333 and S.446, showed that the percentage of their susceptibility ranged from 0 to 19.35 per cent (tables 4 and 5). Furthermore, they were

TABLE 4.—*Results of coffee rust inoculation in the laboratory on four Arabica selections from India* a/ *(Balehonnur strains)*

SELECTION NUMBER	NO. OF PLANTS INOCULATED	NO. OF SUSCEPTIBLE PLANTS	PER CENT SUSCEPTIBILITY
S-288	192	7	3.65
S-333	29	2	6.89
S-446	31	6	19.35
S-795	36	2	5.55

a/ Some of the plants were infected (flecks) but did not produce spores.

TABLE 5.—*Rust reading (artificial and natural infection) on 4 Arabica selections from India*

Selection Number	Total Seedlings Planted	No. Living at Rust Reading	Category and Number for Each					% Infected
			0	1	2	3	4	
S.288 a/	37	37	37	—	—	—	—	0.00
S.333 b/	36	36	35	—	—	1	—	2.78
S.446 b/	36	35	25	—	4	—	2	17.14
S.795 b/	36	35	34	—	—	1	—	2.86
S.288 b/	32	22	22	—	—	—	—	0.00

a/ — Progeny of an S.288 plant already grown in College.
b/ — Part of the batch of seeds (40 lbs.) imported from India in 1957.

also observed by the writers to be more resistant to drought than the African selections. When the progeny of the rust-resistant S.288 tree was inoculated, none of them was infected. This selection is also reputed to be resistant to eelworm attack (Haarer, 1956).

Other promising rust-resistant selections bear P.I. accession numbers 205107 (Dilla & Alghe), 207629 ("Kaffa" S.12), 205112 (Kent's), and 213453. The bearing trees of these selections exhibited moderate resistance, or the so-called "field resistance," but their progeny showed a higher degree of heterozygosity for resistance to rust.

Among the hybrids, the seedling-progenies of plant number 387 (*C. arabica* x *C. dewevrei*) from Brazil and Kawisari B. (*C. arabica* x *C. liberica*) were found to be highly resistant to *Hemileia* infection. The latter was introduced into the Philippines by Mendiola (1931) and was known to be resistant to coffee rust in Java. Another apparent hybrid which was also highly resistant to the disease but behaved very similarly to Kawisari B was P.I. number

209850. None of the seedling-progeny of these hybrids was susceptible to rust infection.

The other species, *Coffea eugenoides, C. liberica-abeokutae, C. ligustroides, C. stenophylla,* and *C. canephora* were highly resistant to the rust disease. However, it was not uncommon to see extremely rust-susceptible Robusta or Excelsa trees growing sporadically in coffee areas of this country. The writers also found that seeds of a susceptible Excelsa tree gave 28.57 per cent rust-susceptible seedlings and that seedlings from seeds of a rust-resistant Excelsa tree were all resistant to rust.

Aside from being susceptible to rust, plants bearing accession numbers 205110 and 205119 ("Harar" types) were also extremely susceptible to *Cercospora coffeicola* infections. The severe infection of the leaves, twigs and berries completely debilatated the trees and caused them to die after two consecutive years of heavy infection. Observations on all the trees bearing the same accession number but planted in different places in the country showed the same reaction which seems to indicate that susceptibility to Cercospora spot is homozygous. These observations corroborate the report of McDonald (1936) and Haarer (1958) that the Harar variety of Arabica is abnormally susceptible to *Cercospora coffeicola* and appears also to be susceptible to *Hemileia vastatrix.*

LITERATURE CITED

AFRICA, E. M. 1918. The minimum Bordeaux application for the control of Hemileia. Philippine Agriculturist and Forester *6* : 251-271,

BARTOLOME, R. 1950. Coffee production in the Philippines. Phil. Jour. Agric. *15* (3-4) : 219-233.

BRIZI, A. 1934. Coffee in 1931 and 1932: Economic and technical aspects. Internat. Inst. of Agric. 231 pp.

CARVALHO, A. 1958. Recent advances in our knowledge of coffee trees, 2. Genetics. Coffee and Tea Industries and the Flavor Field *81* (11): 15-19.

DAVID, P. A. 1926. The coffee industry in the Philippines: Its decline and its partial recovery. The Amer. Chamber of Commerce Jour. *6* (1): 17-18.

———————. 1928. Introduced coffee lose resistance to the rust fungus, *Hemileia vastatrix* B. et Br. Philippine Agriculturist *17* : 45-49.

Di FULVIO, A. 1947. The world's coffee: Studies of the principal products of the world. No. 9. Internat. Inst. Agric. FAO, Rome.

HAARER, A. E. 1956. Modern coffee production xiv -|- 467 pp. Leonard Hill Books Ltd., London.

KRUG, C. A. 1958. The supply of better planting material. ARABICAS. Coffee and Tea Industries and the Flavor Field. *81* (11): 52-57.

———————— and A. CARVALHO. 1952. Coffee breeding. Reprint from Rept of 13th Internat. Hort. Cong.

MAYNE, W. W. 1930. Seasonal periodicity of coffee leaf disease (*Hemileia vastatrix* B. & Br.). Mysore Coffee Expt. Sta. Bull. *4* : 1-16. (Abst. in Rev. Appl. Mycol. 10 : 239).

————————. 1932. Physiologic specialization of *Hemileia vastatrix* B. & Br. Nature *129* : 510.

————————. 1956. Annual report of the coffee scientific officer, 1935-1936. Mysore Coffee Expt. Sta. 14 : 21 pp. (Abst. in Rev. Appl. Mycol. 15 : 798).

McDONALD, J. 1936. The susceptibility of Harar Coffee to disease. Mon. Bull. Coffee Bd. Kenya *2* (22): 191. (Abst. in Rev. Appl. Mycol. 16: 170-711.

MENDIOLA, N. B. 1931. The Kawisari B coffee introduced in the College of Agriculture. Philippine Agriculturist *20* : 101-150.

d'OLIVEIRA, B. 1955. As ferrugens do cafeeiro. Revista do cafe Portugues, Ano. II. No. 7: 9-17.

————————. 1958. Selection of coffee types resistant to the Hemileia leaf rust. Coffee and Tea Industries and the Flavor Field *81* (11) : 112-120.

VENKATARAYAN, S. V. 1946-47. Diseases of coffee. The Mysore Agric. Jour. 25 (1 & 2) : 3-20.

WARD, M. H. 1881. On the morphology of *Hemileia vastatrix* Berk. et Br. (The fungus of the coffee disease of Ceylon). Quart. Jour. Micros. Sci. (n.s. *22*: 1-11.

————————. 1882. Researches on the life history of *Hemileia vastatrix* The fungus of the "Coffee Leaf Disease of Ceylon." Linnean Soc. Jour. Bot. *19*: 299-335.

WELLMAN, F. L. 1953. Some important diseases of coffee. *In* Plant Diseases. U.S.D.A. Yearbook of Agric. 1953 : 891-896.

————————. 1955. Coffee diseases, insects and weeds controlled by chemicals. *In* Pesticides in Tropical Agriculture. Recent Advances in Chemistry Series No. 13 : pp. 43-53.

————————. 1958. Recent spraying for control of coffee diseases. Coffee and Tea Industries and the Flavor Field *81* (11): 106-111.

WICKIZER, V. D. 1943. The world coffee economy with special reference to control schemes. Food Res. Inst., Stanford Univ. of California, U.S.A.

THE SUSCEPTIBILITY OF CYTOPLASMIC MALE STERILE LINES OF CORN TO HELMINTHOSPORIUM MAYDIS NISH & MIY. 1/

A. C. MERCADO, JR. and R. M. LANTICAN

WITH THREE TEXT FIGURES

Twelve standard Philippine inbred lines of corn which were sterilized through the incorporation of cytoplasmic male sterility derived from F44T, an introduced line, were tested for their reaction to Helminthosporium maydis in the wet season of 1961. In all cases, the cyto-sterile versions obtained after four to seven backcrossings were found to be much more susceptible than the normal inbred counterparts..

Male-cyto-sterile lines representing four single-crosses and five double-crosses consistently showed extreme susceptibility to the same disease whereas the normal counterparts manifested conditions of slight to moderate infection only.

A hereditary transmission of susceptibility based on extranuclear inheritance is hypothesized. A factor present in the male sterility cytoplasm is believed to be responsible for the induction of susceptibility.

The cyto-sterile lines of corn, namely, F44T, Oh51AT and 55-1805T possessing the "T" sterility plasmatype have been observed at College, Laguna to be very much susceptible to *Helminthosporium maydis* Nish & Miy. These lines are utilized as a source of cytoplasm which induces male sterility.

A breeding program designed to incorporate the cytoplasmic male sterility factor into some of the standard Philippine inbred lines using F44T as source was initiated in 1957. The backcross method was employed and since, with this system, there is a gradual recovery of the genetic identity of the recurrent parent, it was anticipated that resistance to the Helminthosporium disease would have been restored in the reconstituted cyto-sterile inbred lines.

It appears, however, that even with a sufficient number of backcrossing, the inherent resistance of the normal inbreds could not be recovered. The writers are led to suspect that the cytoplasmic male sterility factor has to do with the expression of susceptibility. This paper will present evidences which suggest that susceptibility is transmitted hereditarily probably through the same cytoplasm causing male sterility.

1/ Central Experiment Station Contribution No. 2814.

MATERIALS AND METHODS

Male sterile lines and their respective normal counterparts representing twelve standard inbred lines, four standard single crosses and five recommended double-cross hybrids were used in the study. The male cyto-sterility factor was derived from F44T, an inbred introduced from Florida, U.S.A. This source material has the "Texas" plasmatype.

The incorporation of cyto-sterility into the standard inbred lines was accomplished through the backcross method. F44T used as seed parent was initially crossed with each of the standard inbreds. The male-sterile F1 individuals and succeeding backcross progenies were repeatedly backcrossed to the respective standard inbred. For each inbred population, individual plants which were found to be recessive for the restoring factors were selected and maintained for use as a source of pollen in the backcrossing program. Conscious selection for male sterility and for the phenotypic characters of the recurrent parent was practiced in the course of backcrossing. Individuals least infected with the disease were also selected.

In the wet season of 1961, the cyto-sterile backcross progenies were grown in 7-meter rows alongside with their respective recurrent parent. The cytoplasmic male sterile single crosses and normal counterparts were grown in replications for comparative purposes. The same procedure was made for the double-cross series.

Disease readings were taken after the silking stage. Ratings were made on the basis of the degree of infection of the individual plants. Arbitrary values were assigned ranging from 1 to 5, in the order of increasing severity of attack, 1 denoting a disease-free condition and 5, a very severe infection.

RESULTS AND DISCUSSION

Conditions in the wet season of 1961 offered an excellent opportunity for the evaluation of the lines for their reaction to the Helminthosporium disease. The disease was epidemically prevalent. Early symptoms were characterizd by the presence of irregularly shaped, reddish-brown to straw colored lesions. At the advanced stage, the spots coalesced, and the leaves as a whole turned light brown, subsequently followed by the general premature drying up of the plant. The seeds, produced as a result of this, assumed a

wrinkled appearance.

The disease ratings made for the inbred lines, single-crosses and double-crosses are shown in tables 1, 2 and 3, respectively. In

TABLE 1.—*The reaction to H. maydis* Nish & Miy. *of* 12 *"Texas" cyto-sterile inbred lines and their standard normal counterparts in the* 1961 *wet season at College, Laguna*

INBREDS	MEAN DISEASE RATINGa/	NUMBER OF ROWS b/	INBREDS	DISEASE RATING	NUMBER OF ROWS
PhIN	3.0	5	Ph19N	1.7	5
Ph1T6	5.0	12	Ph19T5	5.0	5
Ph3N	3.0	5	Ph19T6	5.0	2
Ph3T7	5.0	12	Ph19T7	5.0	4
Ph9N	1.1	9	Ph2N	2.0	2
Ph9T7	5.0	23	Ph2T4	5.0	3
Ph13N	2.9	13	Ph2T5	5.0	2
Ph13T5	5.0	23	Ph2T6	5.0	5
Ph13T6	5.0	4	L.314N	1.3	3
Ph15N	1.5	8	L.314T4	5.0	4
Ph15T5	5.0	6	L.314T5	5.0	6
Ph15T6	5.0	6	L.315N	2.0	13
Ph17N	2.2	10	L.315T6	5.0	29
Ph17T6	5.0	27	L.315T7	5.0	13
F44N	1.8	2	L.316N	2.0	5
F44T4	5.0	2	L.316T5	5.0	3
F44T5	5.0	2	L.316T6	5.0	3
F44T6	5.0	3			

a/ Means were based on 2 repeated readings per row.
b/ 1 row contained approximately 44 plants.

TABLE 2.—*The reaction to H. maydis* Nish & Miy. *of* 4 *cyto-male-sterile single crosses, their normal counterparts and* 2 *varietal checks in the* 1961 *wet season at College, Laguna.*

ENTRY	MEAN DISEASE RATING a/
Ph1T5 x Ph3N	5.0
Ph1 x Ph3	1.0
Ph1T6 x Ph9N	5.0
Ph1 x Ph9	1.0
Ph15T4 x Ph17N	3.5
Ph15 x Ph17	2.2
L.315T5 x L.314N	4.0
L.315 x L.314	1.0
Bicol White Flint	3.8
College Yellow Flint	4.0

a/ Means were based on 2 replications of approximately 40 plants each, 2 repeated readings per replication.

TABLE 3.—*The reaction of H. Maydis* Nish & Miy. *of 5 cytomale-sterile double cross corn hybrids, their normal counterparts and 2 varietal checks in the 1961 wet season at College, Laguna*

ENTRY	MEAN DISEASE RATING a/
(Ph13T4 x Ph17N) (Ph9 x Ph11aRf) b/	3.9
(Ph9 x Ph11) (Ph13 x Ph17)	1.2
(Ph1T4 x Ph9N) (Ph15 x Ph17)	4.0
(Ph1 x Ph9) (Ph15 x Ph17)	1.4
Ph1T4 x Ph3N) (Ph21Rf x Ph17)	4.8
(Ph21 x Ph17) (Ph1 x Ph3)	1.2
(Ph1T4 x Ph9N) (F44 x Ph19Rf)	4.4
(F44 x Ph19) (Ph1 x Ph9	1.2
(L.315T4 x L.314N) (Ph2 x Ph4Rf)	3.5
(L.314 x L.315) (Ph2 x Ph4)	1.2
College Yellow Flint	4.1
Bicol White Flint	2.0

a/ Means were based on 4 replications of approximately 40 plants each, 2 repeated readings per replication.

b/ Rf refers to pollen restoring genes.

the lists are indicated letters N and T to denote, respectively, a normal and a male sterility cytoplasm carried by an inbred. The number immediately following letter T refers to the number of backcross generation.

It is evident in table 1 that all inbred lines possessing the cytoplasm for male sterility proved extremely susceptible to the Helminthosporium disease. The normal counterparts on the other hand showed negligible to moderate infection only. Why the cytoplasmic male sterile lines derived after six and seven backcrossings still showed severe susceptibility has merited attention. For example, in the case of the Ph9 inbred, the cyto-sterile version, obtained after the seventh backcrossing, and the normal counterpart were contrastingly different in their reaction to the disease (fig. 1, 2, and 3).

In a breeding system where the offsprings are continually crossed back to a common parent, the rate of recovery for the genotype of the recurrent parent at each generation, in the absence of selection, follows the series, 1/2, 3/4, 7/8, 15/16, 31/32, etc. In the present case, free recovery is possible. Selection for male sterility could not have acted discriminately towards the inclusion of non-restoring genes (and other loci of the same linkage group)

Fig. 1.—*Helminthosporium-infected male-cyto-sterile Ph9 inbred (ieft) and normal counterpart (right). Note the premature drying up of the cytoplasmic male sterile line. (Photograph taken by the Photographic Division)*

coming directly from F44T owing to the fact that the standard inbreds used as recurrent parent were also carrying non-restoring factors. As the number of backcrossing increased, the non-restoring genes coming from F44T would have been gradually eliminated and replaced by those coming from the recurrent parent. The only factor that was actually being transferred then was that inherent to the cytoplasm.

After the seventh backcrossing, more than 99 per cent of the genetic factors possessed by the recurrent parent would have been recovered in the inbred population. It should be mentioned that in the course of backcrossing, strict selection for apparent resistance and other phenotypic characters of the standard inbred was practiced. If reaction to the Helminthosporium disease were genetically controlled, then the majority of the cyto-sterile backcross progenies should have been as resistant as the normal inbred counterpart. This is expected even under a condition where multiple factors are involved. It should be pointed out that large enough backcross populations (of 200 plants on the average) from which to make selections were grown at each generation. Contrary to expectations, not a single plant in the BC7 population was found

Fig. 2.—*Cytoplasmic male sterile Ph9 (left) and normal counterpart (right)*
(Photograph taken by the Photographic Division)

Fig. 3.—*Upper leaf surface of Helminthosporium-infected cytoplasmic male sterile Ph9 inbred (right) and normal counterpart (left). Photograph taken by the Photographic Division)*

to assume the resistance of its normal counterpart. This holds true for all the cyto-sterile populations. It may be cited that for combining ability, a quantitatively inherited trait, recovery could be achieved as early as the third to the fifth backcrossing (Jones and Mangelsdorf;[2/] Duvick[3/]).

The most logical explanation for the susceptibility of the cytoplasmic male sterile inbreds is one based on extranuclear inheritance. It is hypothesized that susceptibility is controlled by a factor present in the male sterility cytoplasm. This will account also for the unusual uniformity in the degree of susceptibility observed among the progenies at the early and later backcross generations, which otherwise would have been segregating and differentiating for the character.

In tables 2 and 3 are indicated the disease ratings made for the single- and double-cross hybrids. The same trend as in the inbreds was obtained. Lines carrying the cytoplasm for male sterility consistently showed severe susceptibility in both groups. The normal counterparts exhibited relative resistance.

It was observed that while all lines possessing the cytoplasm for male sterility were highly susceptible to the disease, the expression was apparently influenced by the degree of genetic heterozygosis represented by the line. It was most severe among the inbreds, less in the single-crosses and least in the double crosses. Also, the cyto-sterile F1 progenies were not as severely infected with the disease as the cyto-sterile individuals recovered at the fourth and later generations of backcrossing. It is presumed that while the male sterility cytoplasm transmits the susceptibility, the degree of expression is subject to genetic influences, relative to the amount of heterozygosis directly affecting the general level of vigor of the plant. Cyto-sterile lines which represent a high degree of inbreeding would be much more susceptible than those possesing a diverse germplasm.

The main objective in undertaking a breeding program of incorporating male sterility (and restoring genes) into some of the standard inbred lines is to provide a means by which F1 double-cross hybrid seed could be produced without detasseling. Unfor-

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2/ Donald Jones and Paul Mangelsdorf, Production of hybrid corn without detasseling. The Connecticut Agricultural Experiment Station Bulletin 550 (1951.)

3/ Donald Duvick, Yields and other agronomic characters of cyto-plasmically pollen sterile corn hybrids, compared to their normal counterparts. Agron. Jour. 50: 121-125 (1958).

tunately, if susceptibility to the Helminthosporium disease is controlled by the same cytoplasm causing male sterility the hybrid seed that will be produced with this system will be of limited use. Any effort to improve the developed cyto-sterile inbred lines would be futile. The only alternative would be to start all over, using other sources of cytoplasm other than those of the T plasmatype. Other cyto-sterile stocks possessing the S, A, or B plasmatypes will have to be thoroughly tested for their reaction to the major diseases before utilizing any of them. If these plasmatypes would prove susceptible, then it would be necessary to establish the nature of inheritance. Hereditary transmission on a strictly genetic basis would warrant the use of these source materials. Meanwhile, further investigations are being conducted in order to test further the validity of the hypothesized cytoplasmic control of susceptibility.

LYSIMETER STUDIES ON A LIPA CLAY LOAM GROWN TO PADDY RICE
I. LEACHING LOSSES OF SOME SOIL CONSTITUENTS [1/]

EDILBERTO D. REYES, NICOLAS L. GALVEZ,
and NIEVES B. NAZARENO [2/]

WITH ONE TEXT FIGURE

Composite samples of the percolating water collected from the big lysimeter tanks during the first four croppings of paddy rice, Milfor-6, on a submerged Lipa clay loam subjected to different fertilizers and leaching rates were analyzed for their contents of nitrogen, phosphorus, sulfur, chlorine, calcium, magnesium, potassium, sodium, iron, manganese, and aluminum.

The amounts of the soil constituents in the percolates were greatest where the regulated percolation rate of water was highest. The presence of growing rice plants helped minimize leaching losses of the fertilizer elements, N, P, and K; however, losses of the other soil constituents were not necessarily higher from fallow soils than from planted tanks with similar leaching rates. Fallow soils, even after prolonged periods of waterlogging, retained their oxidizing conditions much longer than submerged cropped soils, thus affecting leaching losses of some soil constituents.

The calculated average annual losses of the soil constituents through leaching on a hectare basis were as follows: Mg, 118 kg.; Ca, 116 kg.; Na, 94 kg.; K, 22 kg.; Cl, 28 kg.; S, 20 kg.; N. 4 kg.; P, 0.046 kg.; Fe, 34 kg.; Mn, 7.4 kg.; and Al, 0.81 kg.

The movement of water in soils have long been widely studied with the use of lysimeters. These studies have been oriented essentially towards the determination of the water requirements of cultivated crops. However, they have also been adapted to measure the removal of soil constituents through leaching, one of the several ways by which essential plant nutrients are lost from the soil.

Lysimeter investigations have shown that several factors influence the magnitude of loss of the nutrients through leaching. Such factors include variations in the properties of the soil, the

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2/ The writers are grateful to Dr. J. G. Davide and Mr. S. N. Tilo for their valuable suggestions and criticisms of the manuscript; to the former Cornell visiting Professors N. C. Brady. M. G. Cline, and L. E. Nelson for their helpful suggestions during the early phases of the investigations; and to the many others who helped in the conduct of the experiments.

cultural and management practices employed, fluctuations in the weather conditions, and the chemical composition of the irrigation water used. Kohnke *et al.* (1940), Morgan *et al.* (1942), Kilmer *et al.* (1942), Kardos (1947), and Allison *et al.* (1959) have done exhaustive lysimeter studies on relatively better-drained soils.

In a lysimeter experiment on fertilized paddy soils, Liu *et al.* (1957) found that under water-logged conditions, nitrogen was lost principally as ammonia-N with insignificant losses of nitrate-N. They also found that the amounts of phosphorus, potassium, and sulfate-sulfur leached were greater during the first than during the second season.

One of the notable features in paddy rice culture is the presence of standing water on the surface of the soil. The different physical, chemical, and biological changes occurring in soils are greatly affected by the amount of water present. The conditions and the environment of plant roots in paddy soils, therefore, are markedly different from those obtaining in better-drained soils.

As yet, there is a dearth of information regarding the movement of nutrients in paddy soils; hence, the present paper.

MATERIALS AND METHODS

Lysimeter Set-up and Operations

The "filled-in" lysimeters used are located behind the Department of Soils building at the U.P. College of Agriculture, College, Laguna. There are 31 big and 39 small cylindrical concrete tanks with funnel-shaped bottoms connected to drainpipes leading to an underground chamber where the waters percolating through the soils are collected (fig. 1). The big tanks have an average depth of 71 cm. and a diameter of 76 cm., while the small tanks have an average depth of 31 cm. and a diameter of 51 cm.

Each lysimeter tank, coated inside with asphaltum paint, was lined with quarried gravels, about 2 inches in diameter, and then overlain by a 2-inch layer of finer gravel. The tanks were filled with air-dry soil on April 20, 1955.

Only the results of the chemical analysis of the percolates obtained from the big tanks are reported in this paper.

The soil used. The surface soil of a Lipa clay loam was collected from the Central Experiment Station field. It is essentially

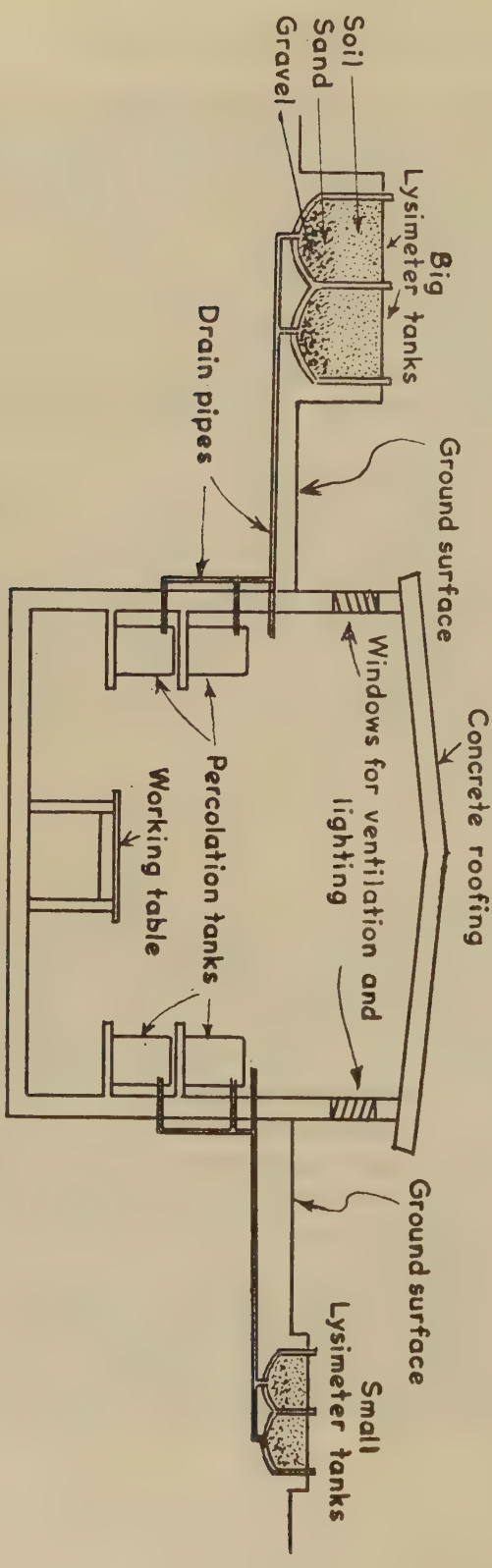

Fig. 1.—*Cross-sectional view of the lysimeter.*

a residual soil from volcanic tuff which, however, was intermixed with alluvial materials from basaltic rocks brought down through erosion from the higher slopes in the surrounding area.

The bulk samples collected were air-dried and ground to pass through a 1-centimeter sieve and then mixed thoroughly. The big tanks contained 255 kg. of this soil. After filling, the tanks were flooded with tap water to simulate conditions under lowland rice culture. The water level was maintained at about two inches above the soil surface until planting on July 5, 1955.

The chemical analyses of the soil are presented in table 1.

TABLE 1. —*Chemical analyses of Lipa clay loam used in the lysimeters* a/

pH	5.60	
Organic matter	2.11	per cent
"Troug" available P	16.88	ppm.
Cation exchange capacity	30.08	m.e. per 100 gm. soil
Exchangeable Ca	15.20	„ „ „ „ „
„ Mg	7.30	„ „ „ „ „
„ K	0.46	„ „ „ „ „
„ Na	0.30	„ „ „ „ „
„ Mn	0.06	„ „ „ „ „

a/ Analyzed in the Soil Service Laboratory of the Department of Soils, U.P. College of Agriculture, College, Laguna.

Treatments studied. Eight treatments, which were replicated three times and laid out in a completely randomized design, were studied. The treatments included fertilizer and leaching variables.

One-third of the nitrogen rate and all of the phosphorus and the micronutrients, iron and manganese, were applied immediately before planting. These were intimately mixed with the first six inches of the soil. The second third-portion of N was applied at tillering and the rest at booting.

Seven hills of "dapog"-grown seedlings of Milfor-6, a non-lodging and early maturing variety of rice, were planted in each tank. Having two seedlings each, these hills were spaced about 25 cm. from each other.

The collection of regulated volume of percolating water was initiated 10 to 14 days after planting and continued up to 10 to 7 days before harvest. The volume of the percolate drawn daily from the 1/4-inch percolation per week rate amounted to 414 milli-

liters.

The dates of planting and harvesting as well as the total volume of percolate collected per tank based on the 1/4-inch percolation per week rate for the first four croppings were recorded as follows:

Cropping Number	Season	Date of Planting	Date of Harvesting	Liters of Percolate
First	1955 Wet	July 5, 1955	October 24, 1955	36.4
Second	1955 Dry	December 5, 1955	March 26, 1956	43.9
Third	1956 Wet	July 14, 1956	November 6, 1956	39.0
Fourth	1956 Dry	December 12, 1956	April 10, 1957	41.4

Aliquots representing five per cent of the total volume for each bi-weekly period were measured, treated with xylene, and stored in one-gallon brown bottles. These were composited after each cropping.

Total nitrogen, potassium, sodium, sulfur, and chlorine were determined on the original composite samples of the percolates. The phosphorus, calcium, magnesium, iron, aluminum, and manganese contents of the percolates were determined on concentrated composite samples treated with amixture of concentrated nitric and hydrochloric acids.

Total N was analyzed according to a modified Gunning method (AOAC, 1950), K and Na by the use of a Beckman Model DU flame photometer [3/], S by the barium sulfate turbidimetric method (Chesnin and Yien, 1950), and Cl by the Volhardt method (Kolthoff and Sandell, 1947). Phosphorus was analyzed by the molybdenum blue colorimetric method; Ca by the oxalate-permanganate titration method; Mg by the sulfuric acid-sodium hydroxide titrimetric method on precipitated magnesium ammonium phosphate; and Mn was determined colorimetrically after the characteristic permanganate color was developed with sodium meta-periodate. These methods of analyses were adapted from those proposed by Peech *et al.* (1947). The Fe and Al contents were determined colorimetrically using ortho-phenanthroline and aluminon reagents, respectively (Peech and English, 1944).

RESULTS AND DISCUSSION

The mean concentrations of the different soil constituents and

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3/ Analysed by Mrs. Salud Sanchez-Cruz of the University of the Philippines Central Experiment Station Analytical Laboratory whose help the writers gratefuly acknowledge.

their corresponding magnitudes of loss in the percolates collected during the first four croppings of paddy rice are presented in tables 2 and 3, respectively.

There were no appreciable differences in the mean concentrations of the soil constituents in the percolates drawn from the planted treatment tanks (table 2). However, losses from tanks subjected to the higher rate of leaching were greater. The mean losses from the planted tanks subjected to 1/4-inch leaching rate were only about one-fourth as much as those from tanks with 1-inch rates (table 3).

Average Losses of Soil Constituents Between Treatments

Nitrogen, phosphorus, sulfur, and chlorine. Between tanks with the same leaching rate, the average loss of N was greatest from the uncropped tanks. Nitrogen removed from the cropped tanks averaged 62 mgm. per tank only while that from the fallow tanks averaged 131 mgm. The marked difference would indicate that plants helped minimize leaching of N from the soil. It may be mentioned at this juncture that the statistical analysis of the yield data showed significant increases in yields due to N application.

The average amount of P removed from the unplanted tanks was slightly higher than that removed from the unfertilized, planted tanks suggesting that the presence of plants tended to minimize as well the losses of P through leaching.

The amount of P lost from the cropped tanks subjected to the lower percolation rate averaged 0.77 mgm. per tank. The highest level of P occurred in the percolates from Treatment H (60-45-0 plus iron chelate) which may be attributed to the complexing action of the added chelate on ions, such as iron and aluminum, resulting in the increased solubilization of P.

Sulfur losses were higher in percolates from the fallow tank, averaging 602 mgm., whereas those from the planted tanks with similar leaching rate averaged only 175 mgm. Since the start of the experiments, no organic residue has been incorporated into the soils in the fallow tanks. A more oxidizing condition therefore would have prevailed in the submerged fallow soils than in the submerged cropped soils. The easily-leached sulfate ion is the predominant ionic form of S in soils which are highly oxidizing, whereas in paddy soils, the stable ionic form is the sulfide, which is usually rendered non-toxic to plants through precipitation by reduced forms of iron. The inference is supported by the relatively lower losses of S from iron-treated soils, being only 91 and 148 mgm. from

TABLE 2.—*Mean concentration of the soil constituents in the percolates during the first four croppings with Milfor-6 in the big lysimeter tanks*

FERTILIZER TREATMENTS a/	PERCOLATION RATES Inch/Week	N	P	S	Cl	Ca	Mg	K	Na	Fe	Mn	Al b/
						Parts/Million						
A. 0-0-0c/	¼	3.28	0.020	14.8	11.2	41.8	50.0	13.3	39.4	7.7	2.29	0.50
B. 0-0-0	¼	1.58	.015	6.5	14.3	39.7	52.3	10.2	41.0	9.7	2.12	.31
C. 0-45-0	¼	1.60	.019	4.0	9.8	49.6	50.1	10.3	43.3	12.2	2.23	.24
E. 60-45-0	¼	1.29	.016	4.7	10.4	44.2	52.5	9.2	39.6	11.1	2.26	.26
F. 60-45-0	1	1.55	.019	12.7	12.8	55.4	44.8	8.8	34.7	20.7	4.27	.36
G. 60-45-0 plus 5 ppm Fe (Fe as Ferric chloride)	¼	1.56	.021	2.3	14.7	44.4	50.7	8.5	37.0	11.4	2.38	.30
H. 60-45-0 plus 5 ppm Fe (Fe as Iron chelate)	¼	1.71	.023	3.7	11.7	43.7	53.1	9.4	48.2	15.5	2.44	.42
I. 60-45-0 plus 5 ppm Mn (Mn as MnSO4.H2O)	¼	1.65	.019	4.4	11.0	45.0	51.9	10.0	42.8	8.7	2.46	.27
M E A N		1.78	0.019	6.6	12.0	45.5	50.7	10.0	40.8	12.1	2.56	0.34

a/ Rates indicated are in kg. of N, P205 and K20 per hectare.
b/ Based on the analysis of the percolates from the first and second croppings only.
c/ Not cropped to rice (Fallow treatment).

TABLE 3.—*Average losses of soil constituents through leaching during the first four croppings with Milfor-6 in the big lysimeter tanks*

FERTILIZERS TREATMENTS a/	PERCOLATION RATES Inch/Week	N	P	S	Cl	Ca	Mg	K	Na	Fe	Mn	Al b/
						milligrams/tank						
A. 0-0-0c/	¼	131	0.80	602	429	1666	1991	521	1578	296	90	19
B. 0-0-0	¼	62	.61	268	538	1585	2082	397	1636	389	85	12
C. 0-45-0	¼	64	.75	167	365	1967	1993	399	1731	495	89	9
E. 60-45-0	¼	51	.67	191	397	1775	2088	356	1579	443	90	10
F. 60-45-0	1	242	3.02	2040	1961	8926	7158	1361	5466	3290	693	57
G. 60-45-0 plus 5 ppm Fe (Fe as Ferric chloride)	¼	62	.87	91	563	1774	2028	328	1470	461	97	12
H. 60-45-0 plus 5 ppm Fe (Fe as Iron chelate)	¼	68	.93	148	442	1771	2113	365	1922	632	98	17
I. 60-45-0 plus 5 ppm Mn (Mn as MnSO4.H2O)	¼	65	.78	173	426	1819	2070	386	1709	346	101	11
M E A N		93	1.05	460	640	2660	2691	514	2136	794	168	18

a/ Rates indicated are in kg. of N, P205 and P20 per hectare.
b/ Based on the analysis of the percolates from the first and second croppings only.
c/ Fallow treatment, no crop.

Treatment G and H, respectively.

Between similarly-leached tanks, the highest average loss of Cl amounting to 563 mgm. occurred in the percolates from tanks receiving additional Cl (Treatment G: 60-45-0 plus ferric chloride). Those from the other tanks averaged 433 mgm. Cl only.

Calcium, magnesium, sodium, and potassium. Calcium removals were higher from the P-treatments than from the no-P treatments. With the former treatments, Ca losses averaged 1821 mgm. per cropping whereas losses averaged 1625 mgm. with the no-P treatments. It is suggested that a part of the Ca incidentally added with the superphosphate could have contributed to the Ca accounted for in the percolates.

The greatest loss of Ca occurred where the leaching rate was highest. Considering the high concentration of Ca in the percolates from these tanks averaging 55.4 ppm., it would not be unwise to suggest that in these experiments the high loss of Ca through leaching essentially follows the principle of mass action.

Percolates from tanks with similar leaching rates had relatively the same concentrations of Mg. The concentrations of Mg in the percolates averaged 51.5 ppm. equivalent to an average removal of 2052 mgm. Mg per tank.

It will be noted that the percolates from tanks with high leaching rates had the lowest mean concentration of Mg. This low magnitude would imply close adherence to the mass-action principle since earlier leachings would have already removed a large amount of soluble Mg originally present in the soil. Despite the low concentration of Mg, the greater volume of the percolates drawn made up for the high average amount of Mg removed from the soil. The average amount of Mg lost was 7158 mgm. per tank as compared to an average loss of 2052 mgm. Mg from the tanks with 1/4 inch percolation rate.

The highest amount of 521 mgm. K per tank was measured in the percolates of the fallow tanks between treatments with similar leaching rates. Potassium losses from cropped tanks averaged 372 mgm. per tank only. This trend of results is quite similar to that observed in the case of N losses.

The fallow tanks did not necessarily lose higher amounts of Na compared to the other planted tanks with similar leaching rates. Sodium losses from the fallow tanks averaged 1578 mgm. per tank, while from the planted tanks, the mean loss averaged 1674 mgm. The highest mean loss of Na occurred in percolates from Treatment

H (60-45-0 plus iron chelate) tanks. It should be mentioned that the iron chelate used was in the form of its sodium salt.

Losses of bivalent cations, Ca and Mg, were in almost all cases greater than those of the monovalent cations, Na and K. Except from tanks subjected to high leaching rates, Mg losses were in all cases higher than Ca losses. For the 1/4 inch percolation rate, the mean Mg loss for the four cropping periods was 2052 mgm. per tank while the mean Ca loss was 1765 mgm. per tank. Between monovalent cations, losses of K were much lower than of Na. The marked difference between the losses of these ions would be attributable to the relatively stronger absorption of K by soil particles and/or the preferential and more rapid rate of uptake of K over Na by plants.

Iron, manganese, and aluminum. The least amount of 296 mgm. Fe was observed in percolates from the fallow tanks. The average amount of Fe leached from the cropped tanks with the same rate of leaching was 461 mgm. per tank. The high loss may be attributed to the incorporation into the cropped tanks of large amounts of plant residues which converted into some forms of chelating organic compounds under the soil's anaerobic conditions, would enhance the mobility of iron. It will be noted that the mean loss of Fe from the chelate-treated tanks was the highest among similarly-leached tanks.

Differences in the amounts of Mn removed from the soils through leaching were comparable among tanks with the same rate of leaching. Although differences may not be significant, it would be worthwhile to point out that the highest loss of Mn occurred in the Mn-treated soils (Treatment I: 60-45-0 plus manganous sulfate, mono-hydrate).

The losses of Al through leaching were rather low. The lowest average loss of Al was observed in percolates from Treatment C (0-45-0) due possibly to the formation of insoluble hydroxy-aluminum phosphates in the soil. The relatively high loss of Al from the chelate-treated tanks may be attributable to a chelation reaction. As in the case of Fe, more Al would be rendered soluble in the soil by chelating agents.

Where reducing conditions prevail as in submerged soils, ferrous and manganous forms of Fe and Mn predominate. These forms are relatively more soluble than their higher-valenced ions, ferric-iron and manganic-manganese. Since the Al ion does not change its valency state under such conditions in the soil, its so-

lubility is not expected to change via an oxidation-reduction reaction. As will be observed from table 3, losses of Fe and Mn were much greater compared to the loss of Al from the soils.

Losses of the Soil Constituents Every Cropping Period

Table 4 shows a comparison of the average losses of the soil constituents through leaching during each cropping period.

The total volumes of the collected percolates varied between seasons. For the eight treatments subjected to leaching, the average volumes of percolates collected were 50.0, 60.4, 53.6 and 56.9

TABLE 4.—*Average concentration and magnitude of loss of the different soil constituents in the percolates over-all treatments per cropping season*

CONSTITUENTS	AVERAGE CONCENTRATION '55 Wet	'55 Dry	'56 Wet	'56 Dry	MEAN
			parts per million		
Nitrogen	2.74	1.56	0.80	2.01	1.78
Phosphorus	.025	.030	.012	.011	.020
Sulfur	.04	4.2	15.6	6.7	6.6
Chlorine	26.9	3.4	7.8	9.9	12.0
Calcium	44.2	44.0	45.1	48.6	45.5
Magnesium	63.4	49.2	39.8	50.5	50.7
Potassium	19.7	7.3	6.5	6.5	10.0
Sodium	44.3	34.9	41.9	42.1	40.8
Iron	12.96	7.75	6.96	20.81	12.12
Manganese	3.27	3.86	1.48	1.62	2.56
Aluminum	0.42	0.26	—	—	0.34

	MAGNITUDE OF LOSS '55 Wet	'55 Dry	'56 Wet	'56 Dry	MEAN ANNUAL LOSS a/
		milligrams per tank			*kg./ha.*
Nitrogen	136	82	37	118	4
Phosphorus	1.24	1.70	.64	.64	.046
Sulfur	1.8	194	1080	565	20
Chlorine	1306	228	428	598	28
Calcium	2215	2995	2648	2783	116
Magnesium	2973	2862	2061	2867	118
Potassium	952	424	328	353	22
Sodium	2160	1933	2150	2302	94
Iron	771	466	543	1396	35
Manganese	184	288	87	113	7.4
Aluminum	21	16	—	—	0.81

a/ Calculated by multiplying the mean magnitude of loss (in mgm. per tank) by the conversion factor, .0438

liters for the 1955 Wet, 1955 Dry, 1956 Wet, and 1956 Dry seasons, respectively. Since the volume of the percolate is considered in calculating the magnitude of losses of the soil constituents, the comparison of losses between seasons becomes more difficult and rather complicated. However, the average concentrations of nutrients in the percolates would serve sufficiently as indices to the comparative losses of the constituents.

The average concentrations of some of the major soil constituents were much higher in percolates collected during the earlier croppings than in those from subsequent croppings. This is especially true with respect to nitrogen, chlorine, magnesium, potassium, sodium, and manganese. It is likely that the air-drying of the soils immediately prior to the start of the experments brought about the release of some nutrient elements into more available forms. Soil organic N and hardly available forms of K are rendered more available by the process of air-drying or by allowing the soil to lay fallow. It is also possible that a change in the water regime of the soil brought about a new state of equilibrium. After most of the soil constituents have been removed either through leaching or through plant uptake during the first cropping period, subsequent removals were conditioned by the capacity of the soil to supply soluble forms of these elements.

On the other hand, the concentrations of some of the elements determined, such as Ca, S, and Fe, were higher in percolates collected during subsequent croppings. The air-drying of soils possibly rendered iron more insoluble while its solubility greatly increased with prolonged water-logging of the soils. The average concentrations of Ca though not varying appreciably between croppings, however, indicate a tendency towards greater losses of Ca in subsequent percolates. The continued application of superphosphate to six of the eight treatments could have resulted in the gradual net accumulation of incidentally-added Ca in the soils. This trend may also explain the higher concentrations of S in subsequent percolates since S is likewise contained in superphosphate.

Nitrogen, phosphorus, sulfur, and chlorine. Of the elements analyzed in the percolates, P was lost the least during all the four cropping periods. Though the solubility and availability of P is generally increased in submerged soils (Ponnamperuma, 1955), results in this study indicate that it is still relatively immobile compared with the other soil constituents. The concentrations of N, Cl, and S in the percolates followed no consistent trend of losses

between croppings. The average annual losses calculated for Cl, S, N, and P were correspondingly 28, 20, 4, and 0.046 kg. per hectare.

Calcium, magnesium, sodium, and potassium. Of the four basic soil constituents, potassium was consistently lost the least over the four croppings. The amounts of Ca, Mg, and Na recovered in the percolates were always greater than those of the other soil constituents. The trend between the losses of Ca, Mg, and Na, however, were not consistent but varied between seasons. The concentrations of Mg, Ca, Na, and K in the percolates averaged 50.7. 45.5, 40.8 and 10.0 ppm., which, on a hectare basis, are equivalent to the annual removal of 118 kg. Mg, 116 kg. Ca, 94 kg. Na, and 22 kg. K.

Iron, manganese, and aluminum. The trend of results on the losses of Fe, Mn, and Al was consistent in the cropping periods studied where the data obtained are complete. The pattern of loss was: Fe$>$Mn$>$Al.

Although the data for Al were obtained on percolates only from the 1955 Wet and 1955 Dry seasons, it is not likely that the losses of Al during the third and fourth cropping periods would exceed those of Fe and Mn. This is due to the fact that, unlike Fe and Mn, Al does not change valency states even when the conditions in the soil become intensely reducing. Consequently, there would be no marked change in Al solubility in submerged soils.

The average levels of Fe, Mn, and Al removed annually per hectare of soil through leaching amounted to 35, 7.4, and 0.81 kg., respectively.

It will be noted that the percolates are richer in Ca, Mg, and Na than in Fe and Al. Highly-leached soils, such as mature soils, therefore would contain clays with more sesquioxides of Fe and Al.

CONCLUSIONS

From the results of the chemical analyses, the following conclusions may be made:

1. The amounts of soil constituents removed from the soil are more or less functions of the volume of water percolating through the soil. Although the high rate of percolation of water through soils may sometimes lead to lowered concentrations of the soil constituents, the greater volume of percolating water makes up for the greater amount of soil constituents removed through leaching.

2. Losses of the soil constituents were not always higher in fallow soils than in soils supporting vegetation. However, allowing the soil to lay fallow resulted in relatively greater losses of the fertilizer elements, N, P, and K, through leaching. The presence of plants helped minimize losses of these nutrient elements.

3. The application of fertilizer materials did not necessarily result in increased concentrations in the percolates of the respective elements. Nitrogen losses were not necessarily high in N-fertilized tanks. On the other hand, the mean losses of Cl, Na, Mn, and Fe among similarly-leached tanks were highest from tanks which received these elements intentionally or incidentally. The addition of superphosphate fertilizers minimized losses of Al from the soil. On the other hand, the application of iron chelates markedly increased the losses of P and Al.

4. Soils which are left fallow even after a long period of waterlogging retained their oxidizing conditions much longer than submerged cropped soils. Since the solubilities of certain soil constituents, such as Fe, are affected by a change in the oxidation-reduction status of soils, the losses of these elements through leaching would likewise be affected.

5. The air-drying of soils affected the level of soluble soil constituents extractable from the soil. Concentrations of N and K were higher in percolates from earlier croppings while that of Fe was higher in percolates collected subsequently.

6. Soil phosphorus even under prolonged submergence is still more immobile than the other soil constituents. Calcium, magnesium, and sodium are removed from soils in much greater quantities than iron, manganese, and aluminum which may result in the accumulation of sesquioxides in highly leached soils.

LITERATURE CITED

ALLISON, F. E., E. M. ROLLER, and J. E. ADAMS. 1959. Soil fertility studies in lysimeters containing Lakeland Series. U.S.D.A. Tech. Bull. *1199*: 1-62. *Cited in* Chem. Abst. *53*: 22655-22656 (1959).

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. 1955. Official methods of analysis. 8th ed., xvi -|- 1008 p. Washington D.C. Assoc. of Official Agric. Chem.

CHESNIN, L. and C. H. YIEN. 1950. Turbidimetric determination of available sulfates. Soil Sci. Soc. Amer. Proc. *15*: 149-151.

KARDOS, L. T. 1947. Lysimeter studies with cultivated and virgin soils under subhumid rainfall conditions. Soil Sci. *65*: 367-381.

KILMER, V. J., O. E. HAYS, and R. J. MUCKENHIRN. 1944. Plant nutrient and water losses from a Fayette silt loam as measured by monolith lysimeters. Jour. Amer. Soc. Agron. *36*: 249-263.

KOHNKE, H., O. R. DREIBELBIS, and D. M. DAVIDSON. 1940. A survey and discussion of lysimeters and bibliography on their construction and performance. U.S.D.A. Misc. Pub. 372.

KOLTHOFF, S. M. and E. B. SANDELL. 1947. Textbook of quantitative inorganic analysis. Revised ed., xvii + 794 p. The McMillan Company, New York.

LIU, P. L., C. T. CHEN, C. T. WEI, and C. S. LIAO, 1957, A lysimeter experiment investigating the effects of applying various fertilizers on the losses of plant nutrients and certain properties of the rice paddy soils. Soils and Fertilizers in Taiwan *5*: 28-29.

MORGAN, M. F., H. G. M. JACOBSON, and S. B. LE COMPTE, JR. 1942. Drainage water losses from a sandy soil as affected by cropping and cover-croping. Windsor Lysimeter Series G. Conn. Agric. Expt. Sta. Bull. *466*: 731-759.

PEECH, M., L. T. ALEXANDER, L. A. DEAN, and J. F. REED. 1947. Methods of soil analysis for soil- fertility investigations. U.S.D.A. Cir. No. 757. 25 p.

PEECH, M. and L. ENGLISH. 1944. Rapid microchemical soil tests Soil Sci. *57*: 167-195.

PONNAMPERUMA, F. N. 1955. The chemistry of submerged soils in relation to the growth and yield of rice. Ph.D. Thesis, Cornell Univ.

THE RESPONSE OF SWEET POTATO TO DIFFERENT FERTILIZER TREATMENTS [1/]

RICARDO M. LANTICAN and PEDRITO M. SORIANO

Two plantings of sweet potato, wet- and dry-season, were made in order to determine the individual and combined effects of nitrogen, phosphorus, potassium, and minor elements on the yield of roots and vines on a Lipa clay-loam soil.

Statistically significant increases in yield of roots due to nitrogen were obtained only when application was increased from the zero level up to the 100 kg. per hectare rate.

Phosphorus at the 90 kg. per hectare application produced a consistently lower yield of roots in both seasons of test, compared to the treatment which did not contain the mineral element.

A significant increase in yield of roots due to the application of 90 kg. of potassium was obtained in treatments which did not receive nitrogen. A consistent increase in the yield of roots and vines was obtained when the quantity of potassium was increased from 90 to 180 kg. per hectare. There was a response in yield of roots to the minor elements.

In the two-season test, the treatment with 100 kg. nitrogen, 90 kg. phosphorus and 90 kg. potassium (all on a hectare basis) consistently gave the highest yields of roots and vines.

Information on the response of sweet potato to fertilizer treatments under Philippine conditions is scanty. Responses in yield due to applications of the mineral elements have been demonstrated in a number of studies conducted abroad.

Increments in yield due to nitrogen application have been obtained (Johnson and Ware, 1948; Edmond and Garrison, 1950; Lana and Peterson, 1956) but in some instances the element, in excessive quantities, caused a significant reduction in yield (Landrau and Samuels, 1951; Paterson and Coruthers, 1957). Increases in yield due to the uptake of phosphorus (Landrau and Samuels, 1951; Lana and Peterson, 1956; Paterson and Coruthers, 1957) and potassium (Scott, 1950; Lana and Peterson, 1956; Paterson and Coruthers, 1957; Duncan, 1958; Thomas and Coleman, 1959) have been demonstrated. Among the three mineral elements, potassium is most needed and phosphorus the least, in root development (Lorenz, 1944; Stino and Lashin, 1953; Paterson and Coruthers, 1957). Significant increases in yield have also been obtained when the

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1/ Central Experiment Station Contribution No. 2816. Prepared in the Division of Field Crops, Department of Agronomy.

plant was treated with boron (Samuels and Landrau, 1952).

To ascertain whether or not fertilization would benefit the crop under local conditions, an experiment was conducted to determine the individual and combined effects of nitrogen, phosphorus, potassium, and minor elements on the yield of roots and vines of sweet potato. It was conducted on a Lipa clay-loam soil at the Central Experiment Station, College, Laguna in 1956 and 1957.

MATERIALS AND METHODS

Vine cuttings of the variety Samar Big Yellow were used. A total of nine treatments constituted the experiment. They are:

Treatment Number	Rates in Kilograms per Hectare		
	Nitrogen	Phosphorus	Potassium
1	0	90	0
2	50	90	0
3	100	90	0
4	0	90	90
5	50	90	90
6	100	90	90
7	50	0	90
8	50	90	90 -|- Cu -|- Zn -|- Bo -|- Mo
9	50	90	180

The three fertilizers used were ammonium sulfate containing 20 per cent nitrogen, superphosphate with 20 per cent phosphorus. and potassium chloride with 60 per cent potash. Other chemicals used were: borax, as a source of boron; copper sulfate, as a source of copper; zinc sulfate, as a source of zinc; and sodium molybdate, as a source of molybdenum. Borax, copper sulfate, and zinc sulfate were applied each at the rate of 5 kilograms to a hectare and sodium molybdate at 50 grams to a hectare.

A completely randomized block design with four replications was used. Each treatment plot consisted of five 7-meter rows set one meter apart. The cuttings were planted 50 centimeters apart in the furrow.

The amount of fertilizer applied to each treatment was computed from the rate per hectare indicated above. To distribute uniformly the minor elements which were in minute chemical quantities, they were thoroughly mixed with one kilogram of well-pulverized soil taken from the respective plots. Phosphorus and the

minor elements were applied at planting time. One-half of the rate of nitrogen and potassium was applied at planting, and the other half was given as side-dressing two months later.

Ten composite soil samples collected at random from each replication were analyzed for N, P, and K contents. The pH was also taken.

The data on yield were taken from the three inner rows. Data on the weight of roots and vines were taken.

There were two plantings made, one during the dry season of 1956 and the other, during the wet season of 1957.

RESULTS AND DISCUSSION

The soil used in the experiment contained considerable amounts of nitrogen, phosphorus and potassium. Upon analysis, it yielded 2446 ppm. of total nitrogen excluding nitrates, 435 ppm. of available phosphorus and 1493 ppm. of available potassium. The pH was at 6.29.

The yield of roots and vines for the two-season test is presented in table 1. The individual analyses of variance in all cases showed statistical significance of the treatment mean square at the 1 per cent level.

TABLE 1.—*Yield of roots and vines, in tons per hectare, of sweet potato in two seasons of test*

TREATMENT (N-P-K)	STORAGE ROOT			VINE		
	Dry Season 1956	Wet Season 1957	AVE.	Dry Season 1956	Wet Season 1957	AVE.
1 0-90-0	4.78	11.20	7.99	1.87	1.71	1.79
2 50-90-0	5.75	12.93	9.34	1.97	1.88	1.92
3 100-90-0	8.78	15.04	11.91	1.64	2.00	1.82
4 0-90-90	6.83	12.19	9.50	1.87	1.98	1.92
5 50-90-90	5.13	11.38	8.25	2.30	2.23	2.17
6 100-90-90	9.75	16.80	13.28	3.07	3.51	3.29
7 50-0-90	6.62	13.32	9.97	2.21	2.34	2.28
8 50-90-90	6.05	14.94	10.50	2.05	2.36	2.20
9 50-90-180	6.48	13.08	9.78	3.23	3.04	3.14
Mean	6.69	13.43		2.25	2.34	
H.S.D. .05%	1.62	2.57	1.55	0.70	0.60	0.42
.01%	1.97	3.10	1.88	0.85	0.72	0.50

The pooled analyses are indicated in the analyses of variance. There was a general consistency in response to the fertilizer treat-

Analysis of variance for yield of roots of sweet potato, wet- and dry-seasons

S. V.	D.F.	M.S.	COMPUTED F-VALUE
Replications (R)	3	8.81	2.39 a/
Treatments (T)	8	98.80	26.78 b/
R x T	24	3.69	0.95 a/
Seasons (S)	1	3,615.91	931.94 b/
T x S	8	8.13	2.10 a/
E r r o r	27	3.88	

a/—Non-significant
b/—Highly-significant

Analysis of variance for yield of vines of sweet potato, wet- and dry-seasons

S.V.	D.F.	M.S.	COMPUTED F-VALUE
Replications (R)	3	0.53	1.96 a/
Treatments (T)	8	10.89	40.33 b/
R x T	24	0.27	0.75 a/
Seasons (S)	1	0.63	1.75 a/
T x S	8	0.50	1.39 a/
E r r o r	27	0.36	

a/—Non-significant
b/—Highly-significant

ments in the two seasons of test as evidenced from the non-significance of the interaction mean square.

Response to nitrogen. The response in yield of roots to three increasing nitrogen levels was non-linear. The 50 kg. application failed to effect a response and significant increases in yield were obtained only at the 100 kg. rate. This type of response pattern to nitrogen was true both for the sets of treatment which received and did not receive potassium. It may be pointed out that a split application of nitrogen was made, one at planting and the other two months after, and it is a possibility that only a portion of the original rate could have been actually made available at certain stages of growth of the plant during which nitrogen is most efficiently utilized for root development. This may account for the non-response of the plant at the lower or 50 kg. nitrogen level.

Vegetative growth was hastened only by the application of 100 kg. of nitrogen in combination with phosphorus and potassium.

Response to phosphorus. There was a depressing effect on the yield of roots as phosphorus was increased from the zero level up to the 90 kg. rate (treatments 5 and 7). As has already been demonstrated in a number of studies (Lorenz, 1944; Stino and

Lashin, 1953; Paterson and Coruthers, 1957), sweet potato does not require very large quantities of phosphrous for root development. Since phosphorus was already present in considerable amount, further addition of the element could have resulted in the accumulation of an excess quantity. Such detrimental effect to the yield of sweet potato, however, should not be taken as a generality for the results were observed only from one pair of comparison and at a relatively low nitrogen level.

No significant difference in vine yield was obtained between the 0 and 90 kg. application of phosphorus.

Response to potassium. To determine the response, four pairs of comparison are available: treatments 1 and 4; 2 and 5; 5 and 9; 3 and 6. A significant difference in yield of roots between the 0 and 90 kg. rate in favor of the latter was obtained only in treatments where no nitrogen application was made. A consistent increase in the yield of roots and vines was obtained when the quantity of potassium was increased from 90 to 180 kg., indicating that sweet potato is a heavy user of the element. Significant increment in vegetative development resulted from the application of 90 kg. of potassium in the presence of nitrogen and phosphorus.

The inconsistency of response of sweet potato to the 0 and 90 kg. applications of potassium at different nitrogen levels may represent the interaction relationship between the two elements.

Response to the minor elements. A statistically significant increase in root yield was obtained with the combined application of copper, zinc, boron, and molybdenum (treatments 5 and 8), with no apparent effect on vegetative development.

In the two-season test, the treatment with 100 kg. nitrogen, 90 kg. phosphorus and 90 kg. potassium(all on a hectare basis) consistently gave the highest yields of roots and vines.

LITERATURE CITED

DUNCAN, A. A. 1958. Effect of potassium chloride and potassium sulfate on yield and quality of sweet potatoes. Proc. Am. Soc. Hort. Sci. *71*: 391-398.

EDMOND, J. B. and O. B. GARRISON. 1950. Cooperative studies on the effects of height of ridge, nitrogen supply, and time of harvest on yield and flesh color of the Porto Rico sweet potato. U.S.D.A. Cir. No. *832*: 1-39.

JOHNSON, W. A. and L. M. WAKE. 1948. Effects of rates of nitrogen on the relative yields of sweet potato vines and roots. Proc. Am. Soc.

LANA, E. P. and L. E. PETERSON. 1956. The effect of fertilizer-irrigation combinations on sweet potatoes in Buckner coarse sand. Proc. Am. Soc. Hort. Sci. *68*: 400-405.

LANDRAU, P. and G. SAMUELS. 1951. The effect of fertilizers on the yield and quality of sweet potatoes. Journ. Agric. Univ. Puerto Rico *35*: 71-87.

LORENZ, O. A. 1944. Studies on potato nutrition. II. Nutrient uptake at various stages of growth by Kern County potatoes. Proc. Am. Soc. Hort. Sci. *44*: 389-394.

PATERSON, D. R. and J. M. CORUTHERS. 1957. Fertilizer and starter solutions affect sweet potatoes. Better Crops with Plant Food *41*: 36-42.

SAMUELS, G. and P. LANDRAU. 1952. The influence of fertilizers on the carotene content of sweet potatoes. Jour. Agron. *44*: 348-352.

SCOTT. L. E. 1950. Potassium uptake by sweet-potato plant. Proc. Am. Soc. Hort. Sci. *56*: 248-252.

STINO, K. R. and M. E. LASHIN. 1953. Effect of fertilizers on the yield and vegetative growth of sweet potatoes. Proc. Am. Soc. Hort. Sci. *61*: 367-372.

THOMAS, G. W. and N. T. COLEMAN. 1959. Sweet potatoes need potash. Better Crops with Plant Food *43*: 27.

SOME STUDIES ON NEBURON [1/]

M. R. VEGA and S. R. OBIEN

In the writers' study on weed control, the family of chlorophenoxy acids, as exemplified by 2, 4-D, has been most effective in combating weeds, especially broadleaves and hedges. However, it is not very potent against grasses, the predominant weeds in rice and sugar cane fields. It is for this reason that other herbicides which may work well in these places are being tested.

Neburon, a formulation of 3-(3, 4-dichlorophenyl)-1-methyl-1-butylurea, was considered rather promising. It is a root-absorbed herbicide unlike 2, 4-D which is mainly leaf-absorbed. Species-wise, it is also unlike the latter in that it is non-specific. Specificity may, however, be attained by judicious placement of the herbicide in the feeding zone of the roots. It is on the basis of this prospect that further studies were made with this herbicide.

1. *Morphogenic effects of neburon on rice, "aquingay", and "pulang-pwet".* When given a pre-emergence spray of neburon up to 6 pounds per acre, rice is not inhibited from germinating (table 1). Upon germination, however, the seedlings develop abnormally long coleoptiles and practically no roots. Subsequent leaves are stunted and malformed. Yellowing starts from the old leaves and progresses towards the youngest one. The leaves finally dry up. At the time the leaves turn yellow, a swelling is noticed on the stem just above the ground level. Because of the poor root system and the abnormal swelling of the top, the plants readily topple over.

Morphogenic effects on "aguingay" (*Rottboellia exaltata*) and "pulang-pwet" (*Echinochloa colonum*) are similar to those on rice. "Pulang-pwet" is most drastically affected and rice, the least. "Pulang-pwet" started to die as early as six days after treatment and all the plants were killed at 11 days. Severe effects on "aguingay" and rice were noted three or four days later than in "pulang-pwet" and most of them survived the treatments, except the 6 pound rate.

The foregoing morphogenic effects are reminiscent of the effects of 2, 4-D on plants. It is likely that the 3, 4-dichlorophenyl radical of neburon could bring about an effect parallel to 2, 4-D or

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TABLE 1.—*Summary of the effects of different concentrations of neburon on germination and early growth of rice, "aguingay" and "pulang-pwet"*

Rate of Neburon (lb./A)	Rice							"Aguingay"						
	A[a/]	B	Length of shoot (cm.)		Numer of leaves		Length of roots (cm)	A[a/]	B	Length of shoot (cm.)		Numer of leaves		Length of roots (cm)
			1 [b/]	2	1	2	2			1 [b/]	2	1	2	2
1	79.50	37.73	23.8	39.9	3.0	5.0	10.5	43.0	75.00	13.6	17.1	3.2	4.3	6.1
2	81.75	73.70	19.6	28.8	2.6	4.5	8.6	42.0	83.38	10.6	13.7	2.9	3.3	6.4
4	80.75	89.78	17.1	23.3	1.9	4.4	7.7	41.25	93.33	7.6	18.6	2.5	3.7	5.1
6	81.75	100.00	9.0	0	1.6	0	0	39.50	100.00	6.0	0	2.0	0	0
Control	80.75	0	31.3	38.3	3.6	5.0	9.1	46.50	0	28.5	41.3	3.7	5.8	27.1

Rate of Neburon (lb./A)	"Pulang-pwet"						
	A[a/]	B	Length of shoot (cm.)		Numer of leaves		Length of roots (cm)
			1 [b/]	2	1	2	2
1	72.00	100	—	—	—	—	—
2	63.75	100	—	—	—	—	—
4	64.25	100	—	—	—	—	—
6	52.00	100	—	—	—	—	—
Control	63.25	0	18.4	23.4	4.5	6.8	12.6

a/ A and B represent per cent germination and per cent kill, respectively.

b/ Observations taken 15 days (1) and 23 days (2) after treatment. In "pulang-pwet", all the plants died before the observations were taken.

that this could be degraded into a 2,4-D-like compound.

2. *Effect of precipitation and soil aggregation on neburon.* Being a root-absorbed herbicide, neburon should be in the feeding zone of roots for maximum effects. This implies that in a given soil, the amount of precipitation is critical as a factor which determines at what horizon of the soil the herbicide would be located.

When Lipa clay loam is pulverized and made to pass through a 2 x 2 mm. sieve, a total precipitation equivalent to 1.0 cm. could move neburon to not more than 4 cm. below the surface of the soil (table 2). Increasing this volume up to 4.0 cm. moves neburon

TABLE 2.—*Per cent of rice seedlings 24 days after planting in different columns of three soil aggregates previously treated with 2 gm. of neburon (18.5 per cent) and leached with four volumes of simulated precipitation*

SOIL COLUMNS (*cm.*)	"Fine soil"				"Medium Soil"			
	Volume of precipitation (*cm.*)				Volume of precipitation (*cm.*)			
	1.0 /a	2.0	3.0	4.0	1.0	2.0	3.0	4.0
0-4	100	100	100	100	100	100	100	100
4-8	100	5.26	6.25	10.52	100	100	100	100
8-12	—	—	—	—	—	100	100	100
12-16	—	—	—	—	—	52.94	88.88	76.47
16-20	—	—	—	—	—	—	—	36.84
20-24	—	—	—	—	—	—	—	—
24-28	—	—	—	—	—	—	—	—

	"Coarse Soil"			
	Volume of precipitation (*cm.*)			
	1.0	2.0	3.0	4.0
0-4	100	100	100	100
4-8	100	100	100	100
8-12	100	100	100	100
12-16	100	100	100	100
16-20	—	—	72.22	100
20-24	—	—	—	—
24-28	—	—	—	—

a/ The simulated precipitations are the total of applications of 0.5 cm. at 3 days intervals to the soil aggregates assembled in bamboo tubes. The sectioning of the soil columns into 4 cm. each was done 3 days after the last application of 0.5 cm. precipitation. The sections were placed in cut beer bottles and seeded with rice to test the presence of neburon in the columns.

twice as deep. The result is different when the size of the soil aggregates are bigger. Penetration through soil that could pass through a 6 x 6 mm. sieve and minus the "fine soil" is more than twice deeper than in fine aggregate. It is a little bit more in coarse aggregate or soil particles that can not pass a 6 x 6 mm. sieve.

It is clear from these findings that both the volume of precipitation and the size of the soil aggregates govern to a great extent the movement of neburon down below the surface of the soil. Fields to be treated with this herbicide should, therefore, be harrowed thoroughly to make the soil particles as fine as possible so that even under a heavy rain, neburon may still remain in the upper surface of the soil where it could be most effective against germinating weeds, and the rice seedlings are left unaffected. Likewise, the seeds should be planted deeper (about three inches) so that the roots will be far from the level of neburon.

3. *Effect of light on herbicidal action of neburon.* When neburon is exposed to light it becomes less effective as an herbicide (table 3). An exposure to light for as short as one day could deto-

TABLE 3.—*The influence of light on the effectiveness of neburon on root growth of rice in Petri dishes* a/

DAYS OF EXPOSURE TO LIGHT	HRS. & MINS. OF EXPOSURE TO LIGHT	AVE. LENGTH OF ROOTS (cm.)	% REDUCTION OVER CONTROL	% INCREASE OVER 0-DAY EXPOSURE
0	0	1.00	82.75	—
1	7:35	1.85	68.10	85.00
2	18.00	2.23	61.55	123.00
4	38:24	2.55	56.03	155.00
6	51.47	2.71	53.27	171.00
Control (water)	—	5.80	—	—

a/ Observations were taken 7 days after planting.

xicate neburon by about 14.65 per cent, and if the time is extended to six days the reduction in effectiveness is about twice as much. These calculations are based on root growth of rice germinated on a 0.5 per cent solution of exposed and unexposed materials.

The above experimental results should guide farmers when to spray and what results to expect from their sprayings. Neburon should be applied late in the afternoon or when the day is cloudy. Rain should come within the first two days, otherwise the treatment will become useless because by then light will have it inactive and unable to kill the weeds.

PROGRESS REPORT: EFFECT OF ALUMINUM ON THE GROWTH OF COCONUT AND OTHER PLANTS [1/]

B. T. MERCADO and J. R. VELASCO

WITH FOUR TEXT FIGURES

Coconut and some short-lived dicot plants were grown in sand and treated with varying concentrations of aluminum.

There was no conspicuous morphological difference between the shoot systems of the treated and untreated plants. There was, however, a marked effect of the treatment on the root system of the plant. The aluminum treated plants exhibited rootlets which were brownish, stiff and seemingly dry with numerous dead branches in contrast to the whitish, fresh and sparingly branched rootlets of the untreated controls. It is likely that the toxic effect of continuous accumulation of the element in the roots will be visually reflected in the other parts of the plant, a possibility which is being looked into.

The feasibility of using short-lived indicator plants for detecting available aluminum in the soil was also investigated. Tomato and Melastoma plants seemed suited for the purpose.

This report is intended as the first of a series of studies on the salt tolerance of coconut and some other plants which may serve as short-lived plant indicators of soil fertility in coconut groves.

Common table salt, given in relatively large amounts, has been found to give an invigorating effect on the plant, but, given at a concentration as high as seven per cent NaCl in the tissue, the plant suffered from temporary wilting. At this concentration, other plants like Areca and Mango wilted beyond recovery (Sankaranarayanan, *et al.*, 1955).

Bicol soils contain as high as 15 to 30 per cent total soil aluminum. It is suspected that this element at this concentration acts as a mild poison to the plant, specifically to the roots (Velasco, *et al.*, 1959). In short-lived plants like barley, lettuce, beets and timothy, aluminum acts as plant poison (Gilbert and McLean, 1927). Ruprecht (1915), as cited by Miller (1938), claims that the toxic action of aluminum to clover is due to the localized accumulation of the salt near the root hairs. This leads to the inability of the plant to absorb the other nutrient elements.

1/ Central Experiment Station Contribution No. 2818.

MATERIALS AND METHOD

The coconut seedlings used were four months old, possessing 3 or 4 palmate leaves at transplanting (October 13, 1959). The initial height of the plant ranged from 35 to 100 cm. from the lip of the pot to the tip of the tallest leaf. The nuts were removed prior to the treatment on May 18, 1960. This step was taken to make sure that all elements absorbed came from the culture solution applied in the form of slop.

Two levels of aluminum, arbitrarily designated as low and high, were used. The control plants received only complete Hoagland's solution. During the first six months (May to December, 1960), the treatments of 40 and 80 grams of alum were given weekly, then twice a week from January 1 to February 15, 1961. From thereon, 100 and 200 ppm. Al as aluminum sulfate was used instead of the alum. The application was made daily with frequent flushing of the sand to prevent salt accumulation.

Aluminum was determined in the tissues of the indicator plants following the method given by Sandell (1950). The tissue was wet-ashed using the usual perchloric-sulfuric acid method. The clear solution was taken up in water and made up to volume. Iron was removed prior to the determination by precipitating it with 6 per cent cupferron. The red aluminum lake was developed using 0.2 per cent aurin tricarboxylic acid (aluminon) and the amount of the element was then determined colorimetrically.

RESULTS AND DISCUSSION

The treated and untreated plants are comparable in appearance. They have the same degree of greenness of the foliage; the fronds number about 6 to 7 per plant; the length of the fronds is approximately 200 to 250 cm. and the bole has a diameter of about 30 to 45 cm.

On July 22, 1960, a control and a high Al-treated plant were sampled at random to examine the root system. The control plant gave 146.1 gm. of pencil root and 111.3 gm. of rootlet, or a root-to rootlet ratio of 1.31 while the Al-treated plant had 134.7 and 340.3 gm. of root and rootlet, respectively, or a ratio of 0.396. Roots of both plants were similar in appearance. The leaf to root ratio of the control plant was 1.04 while that of the treated plant was 0.986.

On February 20, 1961, cursory observation was made on the root system of the different plants. The rootlets of the control plants were whitish, fresh and sparingly branched while those of the low and high Al levels possessed rootlets that were stiff, seemingly dry and with numerous dried branches. It is probable that the high concentration of aluminum kills the cells of the absorption region of the roots. As this region dies, a branch root is produced just behind the killed root. The production of branch roots to replace the dead roots, however, cannot keep pace with the rate that the other roots die. This explains the rather large number of dead rootlets in the Al-treated plants. The above observations clearly indicate that the effect of the treatment is first visible in the roots.

Following his lead, it was thought worthwhile to observe the absorption rate of the main roots in the different treatments. On April 25, 1961, uniform roots were selected and immersed in 60 ml. solution of: a) tap water, b) Hoagland's solution, c) 0.8 ppm. Cu, and d) 20 ppm. Al. Table 1 shows the result obtained after a 48-hour period.

TABLE 1.—*Volume of solution absorbed by coconut roots*

SOLUTION	ABSORPTION IN ML FOR 48-HR. PERIOD		
	Control	Low Al	High Al
Tap water	16	7	12
Hoagland's Solution	4	20	20
0.8 ppm.Cu	6	4	12
20 ppm.Al	50	15	18

Hand in hand with this experiment, some plants like tomato, Melastoma and Stachytarpeta were given different levels of aluminum in sand culture. Tomato and Stachytarpeta were grown from seeds while Melastoma was grown from cuttings. The levels used were 0, 10 and 20 ppm. Al.

Melastoma plants showed favorable growth when the culture solution. contained as high as 20 ppm. Al. The leaf blades of the control plants were definitely chlorotic, leaving the midribs prominently green; the tips were scorched; the plants were stunted (fig. 1). The 10 ppm. plants still showed chlorosis of the lower leaves although the younger leaves were dark green. The root system of the plants differed in length and appearance. In the 0 ppm., the root were few, fine and short; the treated plants were long, big and profusely branched (fig. 2).

Though not as conspicuous as the differences in Melastoma,

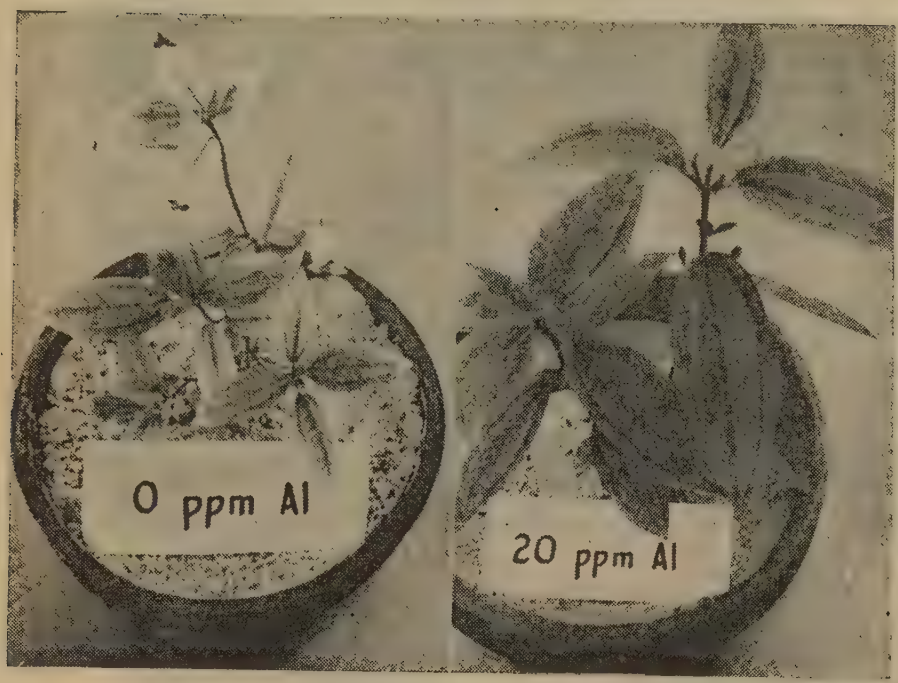

Fig. 1.—*Melastoma plants with (right) and without aluminum (left).*

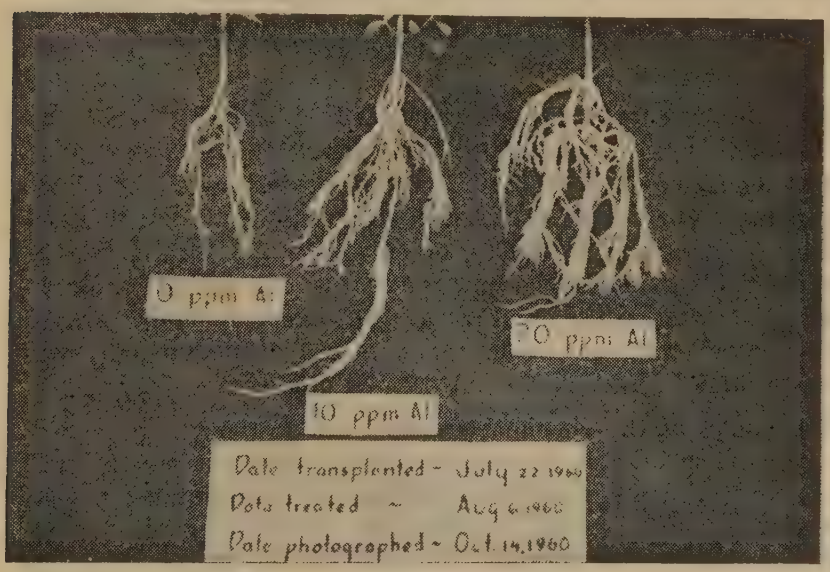

Fig. 2.—*Melastoma roots grown in different levels of aluminum.*

the Stachytarpeta plants treated with higher Al levels possessed darker green leaves, more pigmented petioles and deeper serration of the leaves (fig. 3.) The root systems of the control and treated plants were comparable.

Fig. 3.—*Treated (right) and untreated (left) stachytarpeta plants.*

Generally, tomato plants showed greater sensitivity to the presence of aluminum. The shoots of the control plants were green, the roots long and whitish. One plant possessed nodule-like knots in the roots. The shoots of the treated plants had a purple venation, more conspicuous in the under surface. The terminal leaves cupped-in. This symptom became severe as the concentration increased. Yellowing of the basal leaves was also prominent. Though the roots were white and long, the presence of nodule-like knots was conspicuous in most of the Al treated plants (fig. 4).

The results of the chemical analysis are presented in table 2. Since the sand where the plants were grown was not washed with acid, the control plants could have absorbed some aluminum present as contaminant in the sand. Generally, the roots contained the highest amount of the element, followed by the leaves, then the stem. The amount present in the roots is composed of the aluminum

Fig. 4.—*Tomato plants with (left) and without aluminum (right). Roots are markedly less in the aluminum-treated plant.*

TABLE 2.—*Mean aluminum content of roots, stem and leaves in per cent of the indicator plants in various levels of aluminum*

TREATMENT	INDICATOR PLANTS		
	Tomato	Melastoma	Stachytarpeta
0 ppm.			
Root	0.014	0	0.010
Stem	0.003	0	0.005
Leaf	0.008	0.05	0.006
10 ppm.			
Root	0.014	0.060	0.008
Stem	0.005	0.030	0.006
Leaf	0.008	0.120	0.008
20ppm.			
Root	0.013	0.150	0.012
Stem	0.005	0.070	0.007
Leaf	0.012	0.340	0.010

absorbed by the roots.

The Melastoma plants absorbed the greatest amount of aluminum. This result is in line with the report of Hutchinson and Wollack (1943) that some species of Melastomaceae are aluminum accumulators.

LITERATURE CITED

HUTCHINSON, G. E. and A. WOLLACK. 1943. Biological accumulators of aluminum. Conn. Acad. Arts and Sci. *35*:73-128

McLEAN, F. T. and B. E. GILBERT. 1927. The relative aluminum tolerance of crop plants. Soil Sci. *24*:163-177.

MILLER, E. C. 1938. Plant Physiology 2nd ed. XXX1 -|- 1201 pp. McGraw-Hill Book Co. Inc., New York.

SANDELL, E. B. 1950. Colorimetric determination of traces of metals. 2nd ed. 673 pp. Interscience Publishers Inc., New York.

SANKARANARAYAN, M.P., E. J. VERGHESE and K. P. V. MENON. 1958. A note on the tolerance of salinity by coconut palm. The Indian Coconut Journal *11*:133-139.

VELASCO, J. R., A. HOLASO, R. S. DE LA PEÑA, E. PANTASTICO and V. F. GUEVARA. 1959. Aluminum and its possible relationship to the cadang-cadang of coconut. Philippine Agriculturist *43*:177-199.

NOTE: CYTOLOGY OF PHILIPPINE PLANTS: VI. SANDORICUM KOETJAPE (BURM. F.) MERR.

Sandoricum koetjape (Burm. F.) Merr., locally known as santol, was probably introduced to the Philippines from India or Malaya 1/. It is usually cultivated but is also found growing wild. This fruit tree is widely distributed from northern Luzon to southern Mindanao. Santol fruits have thick outer covering and are edible. The seeds, normally numbering five in each fruit, are large and have translucent or pale, acid, edible pulp of good flavor 2/.

There are two important varieties of santol commonly grown in the Philippines: the "Native" and the "Bangkok". The former is much more widely grown than the latter, which is a later introduction into the country from Bangkok, Thailand by the then Undersecretary of Agriculture Jose Camus and the then Assistant Dean F. O. Santos of the U.P. College of Agriculture in 1949 3/.

Visual observations on the plant characteristics of the "Bangkok" variety revealed that its leaves are larger and darker green than those of the "Native" variety. Its flowers and fruits are likewise larger than those of the "Native" variety.

Young flower buds of both the "Native" and the "Bangkok" varieties were collected from representative trees in the orchard of the Department of Agronomy. Carnoy's fluid A (6 parts 95 per cent ethyl alcohol: 3 parts glacial acetic acid: 1 part chloroform) was used as the fixative. After 24 hours in the fixing solution, the sporocytes were transferred to and stored in 70 per cent alcohol. Cytological studies of the sporocytes were done using the acetocarmine smear technique. Chromosome counts at diakinesis were done with the two varieties.

OBSERVATIONS

The chromosome counts at diakinesis of the "Native" and "Bangkok" varieties of *Sandoricum koetjape* (Burm. F.) Merr. revealed

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1/ E. D. Merrill, "A flora of Manila", 1912, pp. 274-275.

2/ W. H. Brown, "Useful plants of the Philippines", Vol. 2, 1954, pp. 271-273.

3/ Information supplied by Dr. L. G. Gonzalez of the Department of Agronomy, U.P. College of Agriculture.

differences in number. The "Native" variety has a gametic chromosome number of 11 (fig. 1), while the "Bangkok" variety has 22 (fig. 2), indicating that the former is a diploid and the latter, a tetraploid. It was also observed that the pollen mother cells of the "Native" variety exhibit only one nucleolus (fig. 3) in all the cells examined while those of the "Bangkok" variety have cells with one nucleolus (fig. 4a) and also cells with two nucleoli (fig. 4b). Fifty per cent of the PMC examined were with two nucleoli and 50 per cent with only one. The occurrence of two nucleoli in the "Bangkok" pollen mother cells may further indicate the polyploidy of this variety. That "Bangkok" santol is a tetraploid, therefore, accounts for its flowers, fruits and leaves being much larger than those of the "Native" variety.

Except for the differences in chromosome numbers and number of nucleoli, meiosis of the two varieties were observed to be similar. Normal meiotic behavior was evident in the two varieties. In both cases, cytokinesis follows the second meiotic division. Empty pollen grains were very scanty, if there were any observed

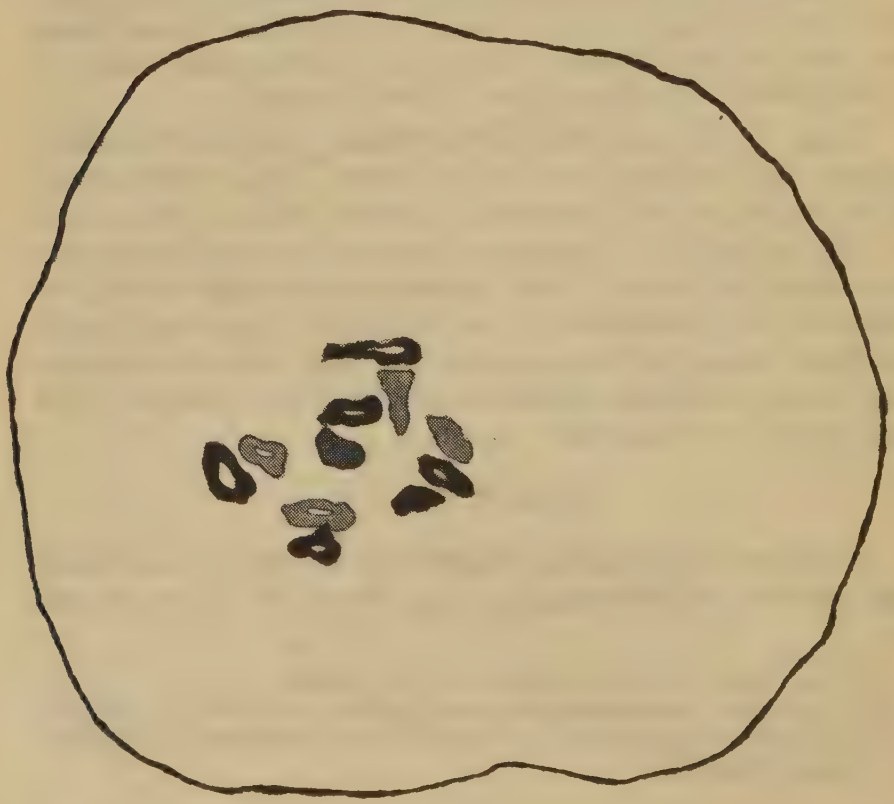

Fig. 1.—*Camera lucida drawing of the PMC of the "Native" variety at diakinesis showing 11 bivalents.*

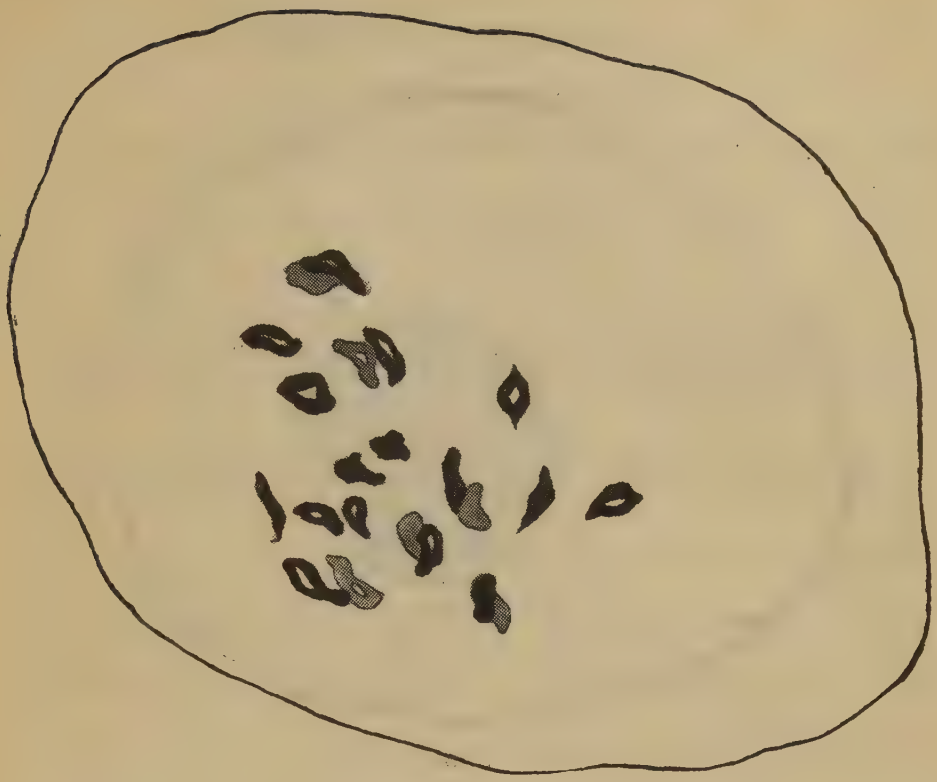

Fig. 2.—*Camera lucida drawing of "Bangkok" santol sporocyte showing 22 bivalents.*

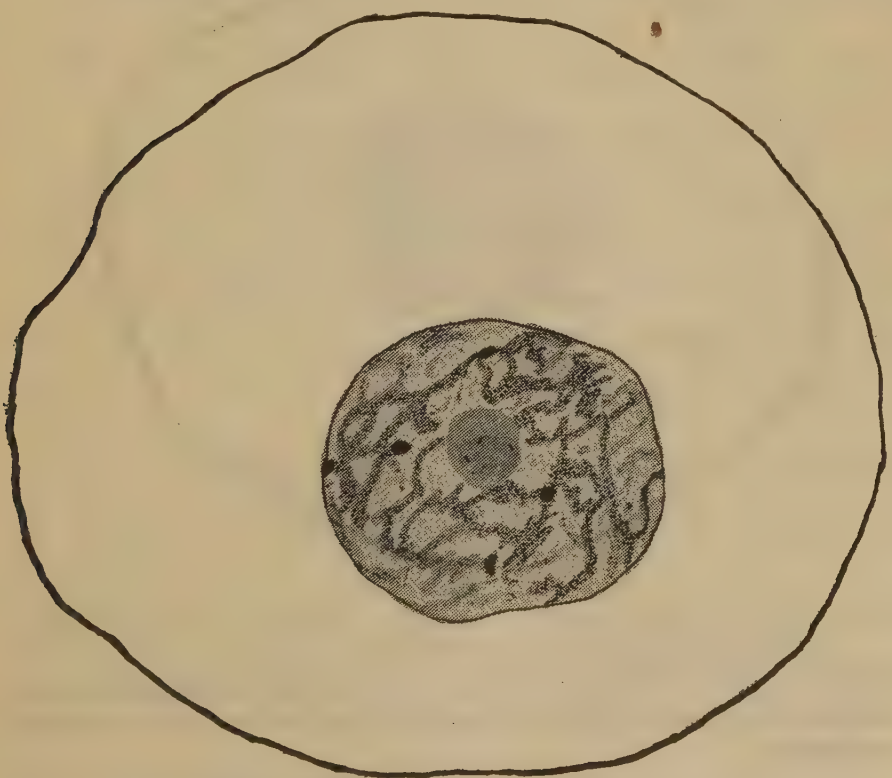

Fig. 3.—*Camera lucida drawing of the PMC of the "Native" variety at early Telophase I showing one nucleolus in a cell.*

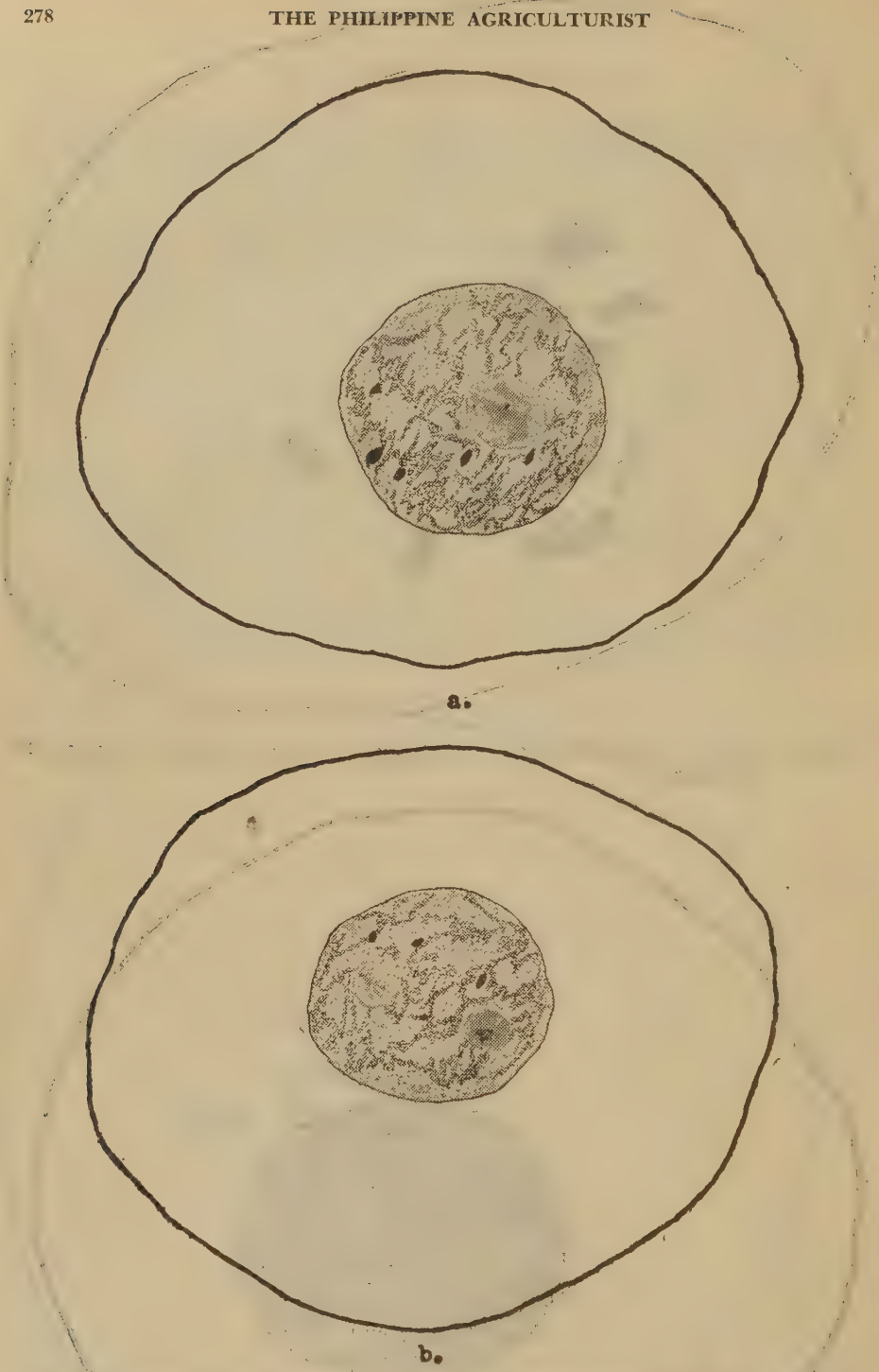

Fig. 4—*Camera lucida drawings of "Bangkok" santol PMC at early Telophase I with a) one nucleolus, b) two nucleoli.*

in some flowers. When the iodine test was conducted, pollen grains stained dark blue, which may indicate that the pollen grains are functional.

—Dolores A. Ramirez

ERRATA

In the June-July, 1961 number of *The Philippine Agriculturist*, the following literature citation for the article, "The Availability of Phosphorus to Rice Grown Under Flooded Conditions as Evaluated by Isotope Dilution", by Jorge S. Davide, was omitted:

BARTHOLOMEW, R. P. 1928. Effect of irrigation on reaction of rice soils. Arkansas Agric. Expt. Sta. Bull. 231.

———————. 1931. Changes in the availability of phosphorus in irrigated rice soils. Soil Sci. *31*: 209-218.

BEACHER, R. L. 1952. Rice fertilizer experiments. Result of tests from 1946 through 1951. Arkansas Argic. Expt. Sta. Bull. 522.

CHANG, S. C. and M L. JACKSON. 1957a. Solubility product of iron phosphate. Soil Sci. Soc. Amer. Proc *21*: 265-269.

———————. 1957b. Fractionation of soil phosphorus. Soil Sci. *84*: 133-144.

CLARK, F. E., and J. W. RESNICKY. 1956. Some mineral element levels in the soil solution of a submerged soil in relation to rate of organic matter addition and lenght of flooding. Sixth Internat. Cong. Soil Sci. Proc., Vol. C, 545-548.

FRIED, M., and L. A. DEAN. 1952. A concept concerning the measurement of available soil nutrients. Soil Sci. *73*: 263-271.

———————— and R. E. SHAPIRO. 1956. Phosphate supply pattern of various soils. Soil Sci. Soc. Amer. Proc. *20*: 471-475.

FUJIWARA, A. 1950. Chemical constitution and availability of iron and aluminum phosphates: I. Tohoku Jour. Agric. Res. *1*: 129-141.

GALVEZ, N. L., T. C. CRUZ, M. E. RAYMUNDO, J. G. DAVIDE and P. A. G. SANTOS. 1956. Response of rice to fertilization in four southern Luzon provinces. Philippine Agriculturist *39*: 439-452.

JANSSEN, G., and W. H. METZGER. 1928. Transformation of nitrogen in rice soil. Jour. Amer. Soc. Agron. *20*: 459-476.

KAPP, L. C. 1933 Study of rice fertilization. Arkansas Agric. Expt. Sta. Bull. 291.

KELLY, W. P. 1914. Rice soils of Hawaii: their fertilization and management. Hawaii Agric. Expt. Sta. Bull. 31

KITSON, R E., and M. G. MELLON. 1944. Colorimetric determinations of phosphorus as molybdivanadophosphoric acid. Ind. Chem. Anal. Ed. *16*: 379-383.

NELSON, L. E. 1957. Problems in fertility research on lowland rice. Jour. Soil Sci. Soc. Phil. *9*: 11-22.

SHAPIRO, R. E. 1958 Effect of flooding on availability of phosphorus and nitrogen. Soil Sci. *85*: 190-197.

In the September, 1961 number, the formula on page 188 in the article. "Determination of the Digestibility of Forage with Plant Chromogens as Indicator", by C. A. Mabasa, Jr., *et al.* should be:

$$\text{Dig. Coef.} = 100 - 100 \frac{(\text{Concentration of chromogen in feces})}{(\text{Concentration of chromogen in forage})}$$

Also. on page 191, the first sentence of paragraph 3 should read: *Trial II.* Digestion coefficients of para grass, *Panicum purpurascens* Raddi, estimated by total collection (mean, 49.86 $\pm$ 1.61 per cent) and grab (mean, 48.81 $\pm$ 1.18 per cent) sampling techniques did not vary significantly.

In the article, "The Flowering Response of Lowland Rice to Natural Photoperiod", by R. M. Lantican and M. B. Parker, the heading of table 1 should be:

PLACE OF ORIGIN	DIFFERENCE IN DAYS								
	0-7	8-15	16-23	24-31	32-39	40-47	48-55	56-63	64.71

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